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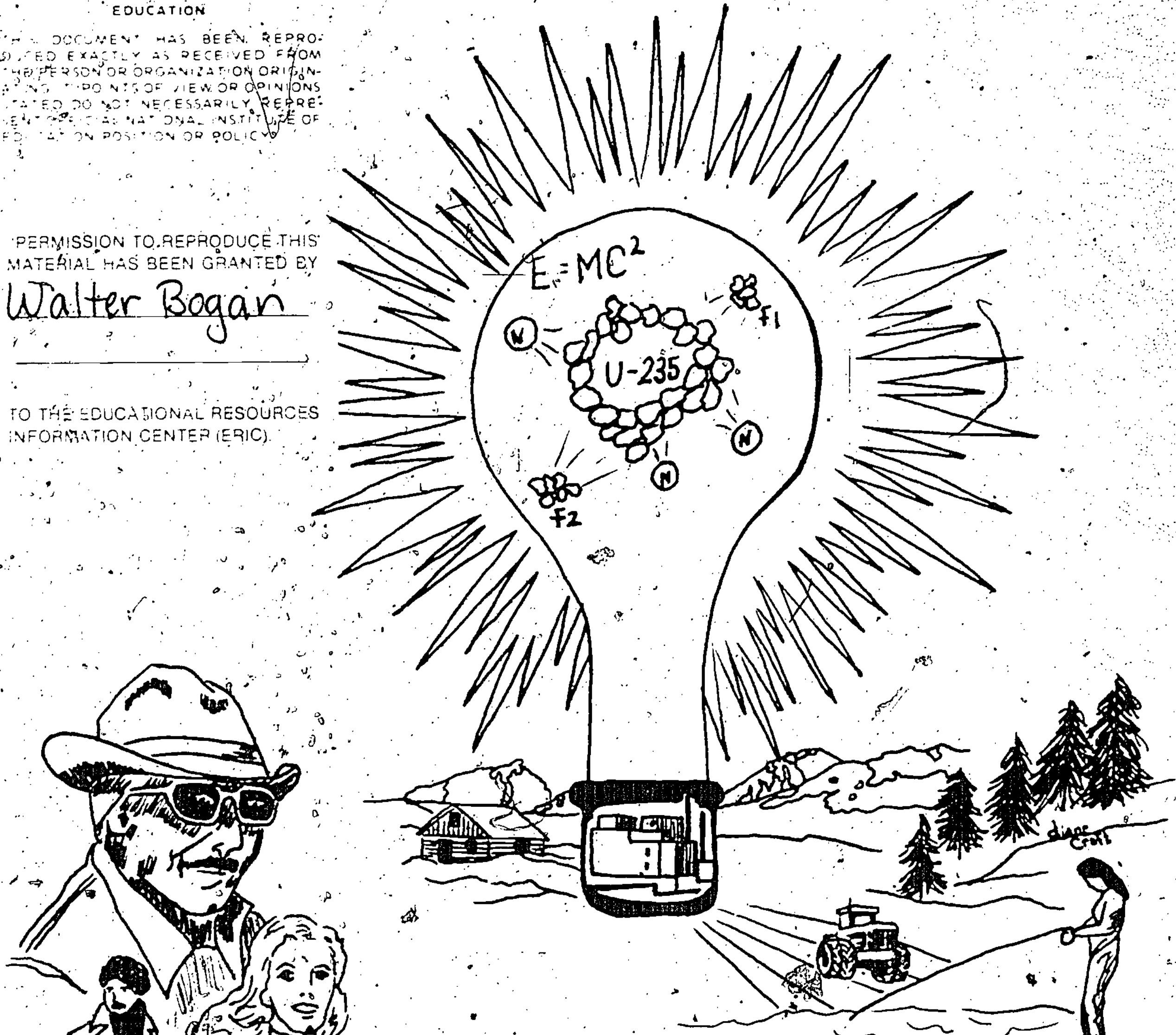
ABSTRACT

Using an interdisciplinary approach, this curriculum focuses on an understanding of: (1) the fundamental principles of operation of a nuclear power plant; (2) the place of nuclear energy in the overall energy-supply-demand situation; (3) risk-benefit balance of the major energy sources; and (4) the role of political action in the development of nuclear energy sources. It is suitable for both high school courses and adults in communities where nuclear energy has become an issue. Technological, environmental, ecological, sociological, economic, and political units as well as a decision making module for use in continuing community action are also included. (Author/DS)

INTERSEC 80-1A

CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY



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73

INTERSEC 80-1A

CITIZEN EDUCATION on NUCLEAR TECHNOLOGY (CENT)

"We understand it."

Sam Volpentest; Hanford, Washington, (local resident)

Written by

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Intermountain Science Experience Center
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CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY

A Message From the Project Director

The Citizen Education on Nuclear Technology (CENT) program was funded by the U. S. Office of Education, and was designed to meet the "...acute public need for information and education about nuclear energy, its benefits, and risks..." It has been classified as an adult education program with applicability, as well, to senior high school students.

M. S. Knowles[1] has defined adult education as "...an adult learning experience should be a process of self-directed inquiry, with the resources of the teacher, fellow students, and materials available to the learner, but not imposed upon him. The learner should be an active participant..." Thus, the CENT program was designed to require a large measure of group participation, in addition to the usual instructional material. The instructional material consists mostly of the technical aspects of the subject presented in non-technical language. The social, environmental, and political aspects, however, are of such a controversial nature that the participants need to investigate them in the context of their own local situation.

Thomas Carlyle, in his history of the French Revolution, has written "risk and win - without risk, all is already lost." Even to do nothing involves a risk. The rule is to base one's actions on the available information to the end that risk can be minimized. Fear develops when necessary information is lacking or withheld. Thus, knowledge dissipates fear. But knowledge alone is not enough - an understanding of the significance of the information is also necessary, and when that significance is understood, one can have confidence in one's actions. Then the actions one takes are in preparation for meeting the contingencies incident to the risks involved. Preparation, therefore, enhances security by minimizing the impact of the necessary risks.

The nuclear energy issue is thus a question of balancing risks against benefits. It cannot, however, be discussed in a vacuum. Its benefits and risks must also be balanced against the benefits and risks of alternative sources. The scope of this program does not admit to an exhaustive study of all possible alternatives, but references will be supplied for those who wish to pursue the subject further. Two sources, coal and solar that are most often

[1] Knowles, M. S., The Modern Practice of Adult Education, Association Press, New York, N. Y. (1970)

suggested will, however, be discussed at some length. The problem, therefore, is to evaluate the alternatives in terms of cost, pollution, and safety.

The cost factor consists not merely of the dollars and cents cost per energy unit, it also consists of the energy cost per energy unit. If ten kilowatt-hours are used to produce one kilowatt-hour of useful energy, one had better think twice (or longer) before employing such an alternative.

The pollution problem is not one of elimination, but of minimization. Only life produces waste; rocks produce no waste, they just lie there. Nature is eminently competent to deal with waste, so long as there is not too much of it in one place at one time. Waste only becomes pollution when Nature's processes become overloaded. To eliminate all waste, it would be necessary to eliminate all life.

Safety, like pollution, is not a question of eliminating all accidents, but of minimizing either the number, the severity, or the consequences of them.

The question, therefore, is, "Given the demand, what alternative will best meet that demand at the lowest cost, the least pollution, and in the safest manner?" The key word in that question is "demand." Again, it is not simply a question of how much; it is a question of "how much, where and when." The geographical distribution of both the demand and the source, and the daily and seasonal variations in demand, determine which alternatives can best meet the country's needs. (See Energy Does Work, Ref. 9, Tech. Unit)

This program, therefore, will explore all such facets of the energy issue, and in particular, nuclear energy as a possible solution to "the question."

The curriculum is divided into five units: A Technology Unit, a Sociological Unit, an Environmental/Ecological Unit, an Economic Unit, and a Political Unit.

The Technology Unit will discuss those technical features of nuclear energy that relate to cost, pollution, and safety. Specific subjects will include the fission process, radiation hazards, and reactor safety. Although it is beyond the scope of this program to engage in such an exhaustive study of other energy alternatives, sufficient data and references will be provided to enable an individual or a group of individuals to make such a study for themselves; in fact, they are encouraged to do so.

The next three units, the Sociological, the Ecological/Environmental, and the Economic units are conceived as working units. Participants in this program are asked to evaluate such items peculiar to their particular situation, as community attitudes, actions necessary in the event of an incident, and community education relating to nuclear power and other alternatives. Civil Defense agencies should be consulted in this connection, since enemy action and nuclear incidents have so much in common that precautionary measures will be identical in both instances. Ecological and economic considerations have meaning only in relation to similar considerations as they apply to other alternatives. This program explores this aspect of the problem.

The fifth, the Political Unit, is partially an informational unit and partially an action unit. The information part deals with the Federal regulations, hearings, and disputes. The action part consists of inquiries by participants directed to city and state agencies relating to similar considerations.

A Decision-Making Strategy Module is provided for use by participants in continuing community action.

It is appropriate at this point to consider Nuclear Energy in the historical perspective.

Other people have also been concerned with the energy situation and have made studies that are reported in the publication New Energy Technology (1971) (Textbooks, 2, Tech. Unit) These authors consider the energy history of the United States from 1850 to the date of writing - 1971. Some of their conclusions are very interesting and are worth repeating.

Historically, the energy supply has consisted of wood, coal, crude oil, natural gas, water power, and nuclear energy. The most significant conclusion is that "past patterns of energy growth or replacement" are similar in many respects to those of today. "The most striking feature of the plot", (a graph not reproduced here) "is the relentless and almost constant upward march of energy consumption, which causes the industrialist or engineer of 1971 to echo the words of his great grandfather, 'Never in history has energy consumption matched ours.'" Three times in this hundred and twenty year history, new fuels have been introduced and integrated into the economy, and the pattern of growth of each has been similar. In 1851, coal contributed 10% of the total energy supply; sixteen years later, it contributed 20%. In 1918, oil contributed 10%, and nine years later, it contributed 20%. For gas, the 10% mark occurred in 1935, and the 20% mark occurred seventeen years later. In 1971, nuclear power was just beginning to come into the picture and the growth rate in 1971 was somewhat comparable to that of petroleum in 1900.

The per-capita consumption of energy as reported by the authors is also of considerable interest. From 1851 to 1885, the per capita rate was nearly constant and then from 1885 to 1920, it doubled. During the last fifty years, however, it has increased by less than 70%. If one assumes an average human caloric intake of 2500 kcal/day, one finds that the 1970 per capita consumption was 80 times the human caloric intake. That is equivalent to having "80 slaves working for each one of us to maintain our modern affluent way of life."

The material for this program has been drawn from a broad spectrum of sources. They are:

1. Copyrighted books of an advocacy nature.
2. Textbooks and monographs on special subjects.
3. Reports of research on special subjects by public and private agencies.
4. Governmental reports of research and records of Congressional Hearings.
5. Journal articles and reports from such organizations as the American Geophysical Union, Atomic Industrial Forum, Environmental Protection Agency, National Science Foundation, and the National Science Teachers Association.

As indicated in one of the foregoing paragraphs, CENT was conceived as a working program. Many of the decisions that need to be made by the citizens of a community relative to nuclear energy are peculiar to that community. Thus, the participants in these workshops are expected to discover what those peculiarities are, guided along the way by the principles and procedures presented in the workshop.

The Project Director, his staff, and the individuals serving in the various advisory capacities, sincerely hope you, the participant, find this program to be informative and helpful, and a valuable guide in assisting you to reach intelligent decisions relative to nuclear energy in your community.

August, 1980

Robert G. Nisle
Project Director
Citizen Education on Nuclear Technology

CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY

TABLE OF CONTENTS

FIGURES

I Technological Unit

II Environmental/Ecological Unit

TABLES

I Technological Unit

II Environmental/Ecological Unit

III Sociological Unit

IV Economic Unit

CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY

"What are fears but voices airy?
Whispering harm where harm is not.
And deluding the unwary
Till the fatal bolt is shot."
William Wordsworth

INTRODUCTION

Fear of the unknown has bothered mankind since the dawn of creation. The questions concerning nuclear energy are no different. To many of us, nuclear technology is an unknown, and thus, many of us harbor fears and reservations about its use. Often times, these fears are played upon by the anti-nuclear lobby in an effort to advance their cause. The purpose of this course is to remove nuclear technology from the category of the unknown and, hopefully in the process, alleviate our fears through the medium of knowledge - knowledge and understanding acquired by a study of the facts examined in the total context of modern society.

The technological intricacies will be studied and in addition, the sociological, environmental/ecological, economic, and political benefits and hazards will be considered. Neither nuclear energy nor any other matter can be intelligently examined in a vacuum. For that reason, this study will look at the total energy picture, including fossil fuels, solar energy, and to a lesser extent, other energy alternatives, as well as nuclear energy. It is intended to provide an understanding of how nuclear power plants work; what some of the environmental effects are of nuclear and fossil fuels; some of the sociological and economic considerations; an explanation of the procedures a utility company must go through before they will be allowed to build and operate a nuclear plant; and, finally, the opportunities you have to influence the decision makers.

There are volumes of material available in all these areas. We hope you will want to sample at least some of them. This course is not intended to answer all your questions, but rather to give you an idea of what questions you should be considering and who should be answering them.

A glossary is included with your text. It should be studied to the same degree as the other parts of the text. It has been placed first, rather than at the end, since the terminology must be learned before the material in the text can be understood.

It is essential that all available information on all alternative sources be considered, if an intelligent decision is to be made. It is the intent of this program, therefore, to present the case for nuclear energy in the total context. To do so, significant aspects of nuclear power generation, and of coal, oil, and natural gas production and use are examined. The best solution in any particular case will take account of all these aspects, and each community must decide for itself what its solution will be.

"No option for providing additional energy supplies for the next twenty years and beyond is without drawbacks. Oil and gas, nuclear power, coal, and even various solar possibilities all entail adverse social, economic, and environmental effects of differing types and magnitudes, on different time scales, and affecting different regions in different ways. Even the 'best' choice for the nation will have drawbacks for some people, in some places." (Energy: The Next Twenty Years, Hans H. Landsberg. Ref. 8, Tech. Unit).

CITIZEN EDUCATION on NUCLEAR TECHNOLOGY

I - NUCLEAR TECHNOLOGY UNIT

"All nature, then, as self-sustained, consists
Of twain things: of bodies and of void,"

. . . .

"Bodies, again,
Are partly primal germs of things, and partly
Unions deriving from the primal germs.
And those which are the primal germs of things
No power can quench; . . . . ."

Titus Lucretius Carus, De Rerum Natura[1]
(95-55 B. C.)

INTRODUCTION

Science and mathematics are, in the minds of a majority of people, relegated to the realm of mystery, and therefore not comprehensible. Perhaps the younger generation has a better understanding because of science or science-fiction broadcasts on television. Still, much misinformation has been widely circulated. Thus, a lack of understanding nourished fears, usually groundless, and has brought about emotional reactions based on what "might be" instead of what is!

A Greek philosopher named Democritus thought a point would be reached at which further divisions of matter would be impossible. He called this particle that could not be divided an "atoma." From atoma, we got our word "atom," something that cannot be cut.

People did not accept the idea for many centuries, but about 300 years ago, scientists again began to think about atoms. Galileo Galilei (1564-1642) of Italy, and Isaac Newton (1642-1724) of England, wrote about their conclusions that all matter was made up of indivisible particles or atoms. There were many others, also. However, people did not accept these ideas during the lifetimes of early scientific pioneers.

The first man credited with expressing definite ideas about atoms was an English school teacher and chemist, John Dalton. He not only had ideas, but he did experiments to prove his conclusions had merit.

Ancients distinguished four "elements," namely fire, water, earth, and air. All substances presumably were made up of some mixture of these. This theory was accepted by Aristotle. It was taught for nearly 2000 years to the

[1] William Ellery Leonard's metrical translation.

time of Galileo. That view was rather vague and interpretation varied among adherents.

Robert Boyle gave the word "element" an interpretation close to the meaning it has today. He said, "substances which cannot be separated into other substances are considered elements." For example, heating sugar will yield a black substance (carbon) and water. Water may be broken down into hydrogen and oxygen gases by passing an electric current through it. Ordinary table salt will be separated by an electric current into sodium and chlorine, neither of which can be further divided by chemical means. Thus, it appears hydrogen, carbon, oxygen, sodium, and chlorine are elements.

The metals generally are elements, such as iron, copper, silver, lead, and gold. A total of 90 elements have been discovered in nature; about 15 more have been made by man.

THE LANGUAGE OF TECHNOLOGY

"Show us the straight path."
The Koran

Anytime you start to learn about something new, you have to learn the language. That is true if you are learning to cook, or drive a car, or learning about nuclear technology.

For the most part, the unfamiliar terms are defined in the glossary, and you can read about them in the context of the material that follows. The first time a term is used, a star (*) is placed after that word, and a definition can be found in the glossary.

Glossary of Terms

atom - A particle of matter whose nucleus is indivisible by chemical means.

barrel - A unit of volume - 1 oil barrel = 42 U. S. gallons = 158.983 liters
1 U.S. liquid barrel = 31.5 U.S. gallons = 1 wine barrel

breeder reactor - A nuclear reactor so designed that it produces more fuel than it uses.

British Thermal Unit (BTU) - An engineering unit of heat and energy; the quantity of heat necessary to raise the temperature of one pound of water one degree fahrenheit.

chain reaction - A fission chain reaction is a nuclear reaction in which a fissionable nucleus absorbs a neutron and splits in two, releasing additional neutrons. These in turn can be absorbed by other fissionable nuclei, releasing still more neutrons and maintaining the reaction.

coal gasification - The conversion of coal to a gas suitable for use as a fuel.

coal liquification - The conversion of coal into liquid hydrocarbons and related compounds, usually by the addition of hydrogen.

conduction (of heat) - The transmission of energy directly from molecule to molecule.

convection (of heat) - The transfer of energy of moving masses of matter, such as the circulation of heated liquid or gas.

coolant - A substance circulated through a nuclear reactor to remove or transfer heat. Common coolants are light water, heavy water, air, helium, carbon dioxide, liquid sodium, and sodium-potassium alloy.

cooling towers - Devices for the cooling of water used in power plants. There are two types: wet towers, in which the warm water is allowed to run over a wooden lattice in a tower and is cooled by evaporation; and dry towers, in which the water runs through a system of tubes cooled by fans and is not in contact with the air.

core - The central portion of a nuclear reactor containing the fuel elements and usually the moderator.

cosmic rays - High energy particles of atomic dimensions from outer space.

critical mass - The smallest mass of fissionable material that will support a self-sustaining chain reaction under stated conditions.

daughter - A nuclide formed by the radioactive decay of another nuclide, which in this context, is called the parent.

efficiency - The efficiency of an energy conversion is the ratio of the useful work or energy output to the total work or energy input.

electron - An elementary particle with a negative charge that orbits the nucleus of an atom. It is only a tiny fraction of the mass of an atom. Chemical reactions consist of the transfer and rearrangement of electrons between atoms.

electron-volt - A unit of energy used to describe neutrons, X-rays, gamma rays, and alpha and beta particles. Because of their diverse nature, an energy unit provides a means for applying a common characterization. Electron-volt is abbreviated eV, and MeV is a million electron-volts.

energy - Energy is the ability to do work. It can be converted from one form to another, but can never be created or destroyed. Common units are calories, joules, BTUs, and kilowatt-hours.

enrichment - A process whereby the percentage of a given isotope present in a material is artificially increased, so that it is higher than the percentage of that isotope naturally found in the material.

fission - The splitting of heavy nuclei into two parts (which are lighter nuclei), with the release of large amounts of energy and one or more neutrons.

fossil fuels - Fuels such as coal, crude oil, or natural gas, formed from the fossil remains of organic materials.

fusion - The formation of a heavier nucleus by combining two lighter ones. As a source of energy, hydrogen (or helium-3) nuclei combine to form helium-4, resulting in a release of energy.

greenhouse effect - The warming effect of carbon dioxide (CO_2) and water vapor in the atmosphere. These molecules do not absorb sunlight but do absorb and retain the infrared (heat) radiation from the Earth.

half-life - The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.

heavy nuclei - In general, the nuclei of atoms of elements heavier than radium.

hydrocarbons - Compounds composed of carbon and hydrogen atoms in various proportions.

in situ - In the natural or original position or location. In situ conversion of oil shale, for instance, is an experimental technique in which a region of shale is drilled, fractured, and set on fire. The volatile gases burn off, the oil vaporizes, then condenses and collects at the bottom of the region, from which it can be recovered by a well. There has also been some experimentation with in situ conversion of coal and oil.

ionization - Removal of some or all electrons from an atom or molecule, leaving the atom or molecule with a positive charge, or the addition of one or more electrons, resulting in a negative charge.

ions - Atoms or molecules with electric charges caused by the addition or removal of electrons.

isotope - Any of two or more species of atoms having the same number of protons in the nucleus (the same atomic number) but with differing numbers of neutrons. All isotopes of an element have identical chemical properties, but different nuclear masses. Since nuclear stability is governed by the relative numbers of protons and neutrons present, one or more isotopes of the same element may be unstable (radioactive). In the usual notation, isotopes of the same element are identified by the total number of neutrons and protons in the nucleus; for example, uranium-235 and uranium-238.

kiloWatt (kW) - A unit of power, usually used for electric power, equal to 1,000 watts.

kiloWatt-hour (kW-hr) - A unit of work or energy. Equivalent to the expenditure of one kiloWatt for one hour.

mass - The quantity of material is known as mass and is the same everywhere, whether on Earth or on the moon.

million electron volts - See electron-volt.

moderating atoms (moderators) - Moderators are elements that have a very small absorption probability, but interact with neutrons by absorbing some of their energy, but not the neutron. The neutron is thus "slowed down" and the lost energy appears as heat. Examples of moderators are deuterium (heavy hydrogen), carbon, beryllium.

molecule - Atoms combined to form the smallest natural unit of a substance. For example, the water molecule is composed of two atoms of hydrogen and one atom of oxygen.

neutron - An elementary particle which is present in all atomic nuclei except for the most common isotope of hydrogen. Its mass is approximately that of a proton, but it has no electric charge. Neutrons are released in fission and fusion reactions.

16

nucleus - The extremely dense, positively-charged core of an atom. It contains almost the entire mass of an atom, but fills only a tiny fraction of the atomic volume.

nuclide - The nucleus in general of any atom of an element.

nuclear reactor - A device in which a fission chain reaction can be initiated, maintained, and controlled.

oil shale - A sedimentary rock containing a solid organic material called kerogen. When oil shale is heated to high temperatures, the oil is driven out and can be recovered.

particulates - The small soot and ash particles produced by combustion.

photovoltaic process - The process by which radiant energy is converted directly into electrical energy. Solar radiation striking certain materials is absorbed, causing separation of electrons from atoms. The migration of these electrons in one direction and of the positively charged electron vacancies ("holes") in the other can produce a small potential difference (or voltage), typically about 0.5 volts.

power - The rate at which work is done or energy expended. It is measured in units of energy per unit of time such as calories per second, and in units such as Watts and horsepower.

proton - An elementary particle present in all atomic nuclei. It has a positive electric charge. Its mass is approximately 1,840 times that of an electron. The nucleus of a hydrogen atom.

radioactive decay - The spontaneous transformation of an atomic nucleus during which it changes from one nuclear species to another with the emission of particles and/or energy. Also called "radioactive disintegration."

solar cell - Converts the electromagnetic radiation emitted by the sun to electricity. The Earth receives about 4,200 trillion kiloWatt-hours per day.

Watt (W) - A unit of power usually used in electric measurements which gives the rate at which work is done or energy expended.

weight - The weight of a material object is a measure of the force of gravity on the mass of that object. Mass is the same everywhere; weight is not the same everywhere.

work - Work is done when energy is used to overcome resistance in the form of either mechanical, electrical, or chemical opposition. Energy is converted to some other form or stored in the process, but not destroyed.

Table I-1 is a list of various energy sources with the units commonly used to measure them.

Selected Definitions from FACTSHEET 18: A GLOSSARY OF TERMS, by the National Science Teachers Association.

Table I-1

Energy Sources and Units

Fuel	Common Measure	Energy Content Variable - Typical Values Shown
Oil	Barrel (42 U.S. Gallons)	5,800,000 BTU per bbl.
Natural Gas	Cubic feet at standard temperature & pressure	1,032 BTU per cu. ft.
Coal	Short ton (2,000 lbs. per ton)	24 to 28 million BTU per ton (12,000 to 14,000 BTU per pound)
Nuclear Fuel	Pounds	331,000,000 BTU per pound fuel enriched to 15% of U-235

13

MATERIALS

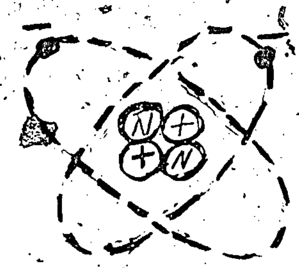
Materials are the stuff of life. They may be solid, liquid, gaseous, hard or soft, light or heavy. They are made up of atoms*, molecules*, neutrons*, protons*, and electrons*.

An element is material composed of identical atoms.

A molecule is composed of two or more atoms of the same or different elements combined in definite proportions.

A compound is a material composed of identical molecules.

Atoms consist of a nucleus* and one or more electrons. The nucleus is made up of protons and neutrons. No one knows what an atom looks like. This drawing is a diagramatic representation of the structure of a helium atom (He).



The electrons have a negative charge, the protons a positive charge, and the neutrons no charge.

All atoms have this same basic structure, differing only in numbers of protons, neutrons, and electrons. The number of electrons in a neutral atom is the same as the number of protons in its nucleus; this number is called the atomic number and identifies the element. A single proton is the nucleus of hydrogen. Two protons and two neutrons is a nucleus of helium, three of each is a nucleus of lithium, eight of each is a nucleus of oxygen, and 79 protons and 118 neutrons is a nucleus of gold.

Within an element, however, (for example, uranium) variations may exist. These variations are called isotopes*. Natural uranium has 3 isotopes, Uranium-234, Uranium-235, and Uranium-238. Neither Uranium-234 nor Uranium-238 is fissionable* by thermal neutrons. Only 7/10's of 1% (0.72%) of natural uranium is Uranium-235, and is thermally fissionable

There are no stable isotopes of any element heavier than lead. Some, however, such as bismuth, thorium, and uranium have such long half-lives that, in comparison with the human life-span, they may be regarded as stable.

Table I-2 is a list of the most abundant elements on the earth, and some of the compounds in which they are found.

Table I-2

Weight Percentage of the Most Common Elements on Earth:

Oxygen (O)	46.6%
Silicon (Si)	27.7
Aluminum (Al)	8.1
Iron (Fe)	5.0
Calcium (Ca)	3.6
Sodium (Na)	2.8
Potassium (K)	2.6
Magnesium (Mg)	2.1
Titanium (Ti)	0.4
Hydrogen (H)	0.1
All Others	1.0
	100.0%

Oxygen and Silicon -	Sand, agate, lavas
Aluminum	Various clays
Iron	Oxides and sulphide ores
Calcium	Limestones
Sodium	Table salt
Potassium	Feldspar minerals (clay)
Magnesium, Calcium	Hard water, limestone, dolomite
Titanium	Semi-precious stones, paints, imitation diamonds
Hydrogen and Oxygen	Water

ELECTROMAGNETIC RADIATION

Radiation is nature's method of moving energy* from place to place. Electromagnetic radiation is a sixty-four dollar word for a phenomenon that people have been familiar with all their lives. Heat, light, and radio waves are all examples. Less familiar forms that you'll need to know about in connection with nuclear power are X-rays and gamma rays.

Even though all these forms of radiation are physically similar, they have different names because of the way by which they are produced. The means for producing heat are familiar to everyone. Light may be produced by a candle, an oil lamp, an electric light bulb, a fluorescent light tube, or by the sun. Radio and TV transmitters are less familiar to the general public, but at least they are no mystery. Most people have had some contact, whether direct or indirect, with X-rays and are therefore aware that the machine that makes X-rays is not at all like the candle that makes light. Both light and X-rays, however, are electromagnetic radiation (EMR).

Gamma rays are usually associated with alpha and beta rays because they are all produced as a result of the break-up of an atom (called radioactive decay* or disintegration). Actually, alphas and betas are not electromagnetic radiations, but particles. Anyone interested in the story of the discovery of these properties can find a very readable account in Asimov's Worlds Within Worlds (Reference I in the Technology bibliography).

What are the effects of low-level radiation on the human organism and the environment? The effects have been impossible to measure because the earth and everything on it have been bathed in low-level radiation since the beginning of time. There is no way of performing an experiment in the absence of these radiations.

Naturally occurring radiation sources include the heavy elements uranium and thorium and their decay products (parents and daughters*), heat, light, radio waves, ultra-violet and cosmic rays*, and the potassium contained in the human body.

It is obvious that low-level radiation has always been with us. In fact, without it, some life processes would be impossible (for example, photosynthesis - the formation of carbohydrates in plants exposed to light).

Ionization*

An atom has been described as having a massive nucleus with one or more orbiting electrons. When one or more of these electrons is removed, the atom is "ionized." When an atom that is a part of a molecule is ionized, the molecule is usually destroyed. The atom that has lost one or more electrons is said to be "excited" and will actively seek to regain the lost electrons. This process can be very harmful in human tissues.

Non-Ionizing Radiation

Simply because a form of radiation is non-ionizing does not mean that it is entirely harmless. All radiation, even though it is essential to life, can be harmful or even lethal when applied in massive doses or at high intensity. Many examples readily come to mind. Sunlight, though useful for sight, can cause blindness if one looks directly at the sun. Ultra-violet light reacts with bodily tissues to produce the essential D vitamin, but under high intensity and prolonged exposure, may cause skin cancer. Radio waves carry our conversations, transmit movies, guide ships and airplanes in darkness and fog, fight disease with artificial fevers, and cook our food. Yet high intensities and prolonged exposure can cause death.

Table I-3 lists the various uses and hazards of EMR.

Table I-3

Electromagnetic Radiation Hazards

Type	Level: Low and Moderate	Level: High to Very High
Non-ionizing		
Very long wave (power frequencies)	Associated long wave source-no apparent effects.	No excessively high sources.
Radio waves	Essential to communications.	Artificial fever; can cause overheating & death.
Infrared (heat)	Photosynthesis. Essential to life.	Severe burns-death.
Visible light	Essential to sight.	Direct sunlight causes blindness; laser light can cause severe burns and blindness.
Ionizing		
Ultra-violet	Fluorescent lights. Produces Vitamin D in humans.	May cause sunburn and skin cancer.
X-rays and gamma rays	Medical diagnostic uses and industrial inspection.	Ionization causes tissue damage or death.

Particle Radiation

Particle radiation appears as a result of radioactive disintegration (break-up) and nuclear fission. Alpha particles have a very short range -- they can even be stopped by a piece of paper; they are very intense, however, and can be very damaging if ingested.

Beta particles are electrons. They have a very small mass and are more penetrating than alpha particles (but less than gamma rays).

Half Life*

Another concept which describes the nature of radiation is the half-life, or rate of disintegration. That is the time required to reduce the quantity of an isotope to one-half the original amount. If the disintegration rate is very high, the substance is said to have a short half-life. Obviously, then, a long half-life indicates a low rate of disintegration. The dose rate is higher, and the hazard greater, in cases of exposure to a short half-life isotope than an equivalent time of exposure to a long half-life isotope.

FISSION

The conversion rate of an element, described as its half-life, is an indication of that element's instability. Another form of conversion can be induced by the addition of a neutron. The fission process of uranium-235 is induced by allowing a slowly moving neutron to approach the atom. The neutron is absorbed and creates such havoc that the nucleus splits in two nearly equal fragments, plus an average of 2.5 extra neutrons. The extra neutrons can be absorbed by other U-235 nuclei, and on and on, in a chain reaction.* This process is not as simple as it sounds. In a nuclear reactor*, some neutrons escape before encountering a nucleus. Some collide with a material called a moderator* (because it slows down neutrons). Some are absorbed by other materials which are specially added to the reactor core.* All of these conditions enable the reaction to be controlled at a specific operating power* level. Very sensitive instruments monitor and maintain the desired level.

The energy released by the fission process is not identical in every case, but averages 200 MeV (200 million electron volts*) per fission. The average 2.5 neutrons per fission are not all emitted at one time. This delay makes it possible to control the power level of the reactor.

Fission Products

Several hundred different species of isotopes are produced by fission in a nuclear reactor. These isotopes are generally not useful and must receive proper disposal. (They could also be regarded as by-products which could be a supplementary source of energy.) Fission products have half-lives which range from very short to very long, and some are even stable. The radioactive isotopes are beta and/or gamma emitters. The most dangerous are those having short half-lives and large gamma energies. High energy betas and gammas are dangerous because of the tissue destruction that ionization causes. Short half-lives are dangerous because they produce more of the damaging radiations in a short time.

Strontium-90 and its short half-life daughter* are dangerous because they result in calcium displacement, and they concentrate in bone. Iodine-137 is also dangerous because it concentrates in the thyroid.

The fission fragments which remain after fission reactions are like the ashes of coal or wood fires. Just as ashes, left to accumulate, can eventually choke out a fire, so fission products can stop the reaction process before the fuel is consumed. The fuel assemblies or rods must be removed from the core and replaced with fresh ones. Although used fuel rods from commercial reactors still contain large amounts of unused uranium that could be reprocessed into new fuel elements, they are not now being reprocessed. (See Environmental Unit - Waste Disposal.)

At first, fission products were stored in underground tanks which had to be cooled to carry off gamma heat. Then a calcining process was developed which changed liquids to solids, making storage much simpler. Recently, a process of casting the solids into borosilicate glass (similar to Pyrex) has been developed, which makes them virtually indestructible. It has been calculated that one cubic meter (little more than a cubic yard) of this calcined material produces enough gamma heat to supply heating for the equivalent of four average homes for one hundred years. Practical considerations, however, make the use of fission products for heating more suitable to large scale applications, such as central systems in large buildings. In such applications, the problem of public acceptance would seem to be the main barrier.

Reactor Safety

The possibility of contamination in dealing with nuclear materials has resulted in the development of procedures and techniques which have a remarkable safety record. A new profession, that of the Health Physicist, has emerged -- a combination of physicist, data clerk, technician, and watch dog. It is the

Health Physicist who is charged with the oversight of all operations in the handling of nuclear materials at a power plant.

In addition to the disposal of fission products and the possibility of contamination in dealing with nuclear materials, the general public is apprehensive of the consequences of a nuclear accident, as at Three Mile Island. The failure to distinguish between an event which is possible and one that is probable is one source of confusion. It is possible that you will be struck by a meteor, but highly improbable. It is possible that a serious accident resulting in many deaths could occur at a nuclear power plant (or a fossil-fueled* plant or a hydroelectric facility) but highly improbable.

Another point of confusion - nuclear power plants cannot explode like a bomb. The physical arrangement of the fuel elements makes such an event impossible. Another kind of explosion which could happen in a nuclear, coal, oil, or gas power plant is a steam explosion. It was feared, but did not happen, at Three Mile Island. There has been one steam explosion in nuclear reactor history, in which three men were killed, in Idaho. No radioactive material escaped to the atmosphere, and traffic was allowed to continue along a major highway less than one quarter of a mile away.

The government and industry have both been involved in reactor safety research since the earliest days of the power development program. Test programs have dealt with simulated accidents, core destruction, reliability of automatic safety systems, etc. The Loss of Fluid Test (LOFT) and the Power Burst Facility (PBF) projects are examples.

One result of the Three Mile Island incident is a reassessment of operating procedures and expanded research programs in reactor safety. A significant finding of the President's Commission on the accident at Three Mile Island (the Kemeny report) was that the incident would have been minor, "...had the operators and management reacted properly..." Further, the Commission reported, "...wherever we looked, we found problems with the human beings who operate the plant, with the management that runs the key organization, and with the agency that is charged with assuring the safety of nuclear power plants." In fact, the report continues, "This Commission believes that it is an absorbing concern with safety that will bring about safety...the human beings who manage and operate the plants constitute an important safety system."

This kind of emphasis on responsibility is something the workshop participant can and should communicate to local nuclear power plant officials. The importance of responsibility was also stressed by Admiral Rickover in testimony before a Congressional Subcommittee after Three Mile Island. He emphasized that total responsibility must reside in a single individual. The Navy nuclear program has been in operation for 26 years, without an accident involving nuclear reactors or the release of any radioactivity which had a significant environmental impact.

As a result of Three Mile Island, industry and government have begun to take steps for the prevention of recurrences. Private citizens can be participants in this process, because a citizen has the right to insist that safety recommendations be followed. Community officials should be continually informed of conditions at the plant. (The effect of releases of radioactive isotopes is covered in the Environmental Unit. For additional technical discussion on reactor safety, the reader is referred to Appendices T-1 and T-2. Appendix T-1 discusses certain factors pertinent to reactor design. Appendix T-2 gives additional details of the Idaho nuclear incident referred to above.)

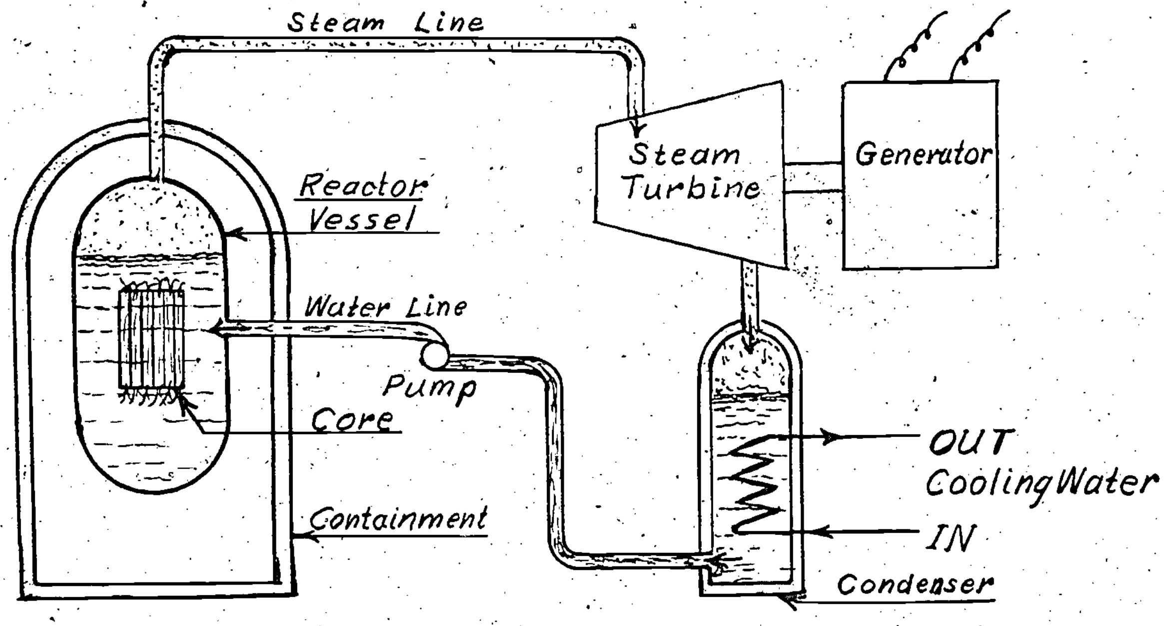
NUCLEAR REACTOR TYPES

Although many designs have been proposed, this section will deal only with general types. High energy neutrons have a low probability of being absorbed by the other atoms or molecules in the reactor. By introducing moderating atoms, the speed of these neutrons is reduced and the probability of absorption is greatly increased. Three general reactor types have been developed. The type selected depends on the energy at which most of the fissions occur.

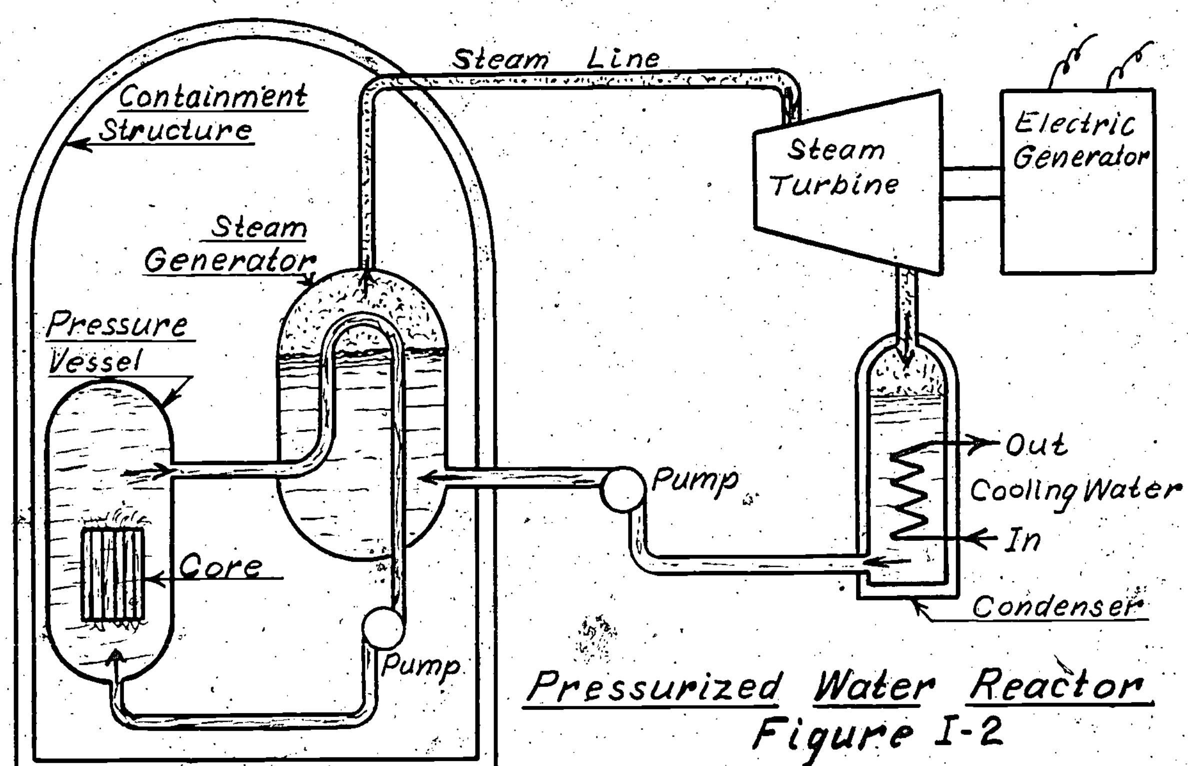
Thermal Reactors. Neutrons must be slowed down in these reactors. (See Figs. I-1 and I-2) Graphite, heavy water, (enriched with deuterium) or light water (distilled water) can be used. Most modern reactors use light water.

Two kinds of thermal reactors are boiling water (BWR) and pressurized water (PWR) types. In boiling water reactors, the water is both moderator and coolant.* The water is allowed to boil in to steam that goes to the turbines to produce electricity. Pressurized water reactors do not allow the water to boil. Through the use of heat exchangers (piping systems), a secondary fluid is converted to steam for use in turbines to produce electricity.

26



Boiling Water Reactor
Figure I-1



Pressurized Water Reactor
Figure I-2

A third thermal type is the high temperature gas-cooled reactor (Fig. I-3). The moderator is graphite; the coolant is helium gas. Steam, which again is produced in heat exchangers, runs the turbines.

Fast Reactors. These reactors use liquid sodium as the primary coolant because it does not slow neutrons appreciably. (See Fig. I-4) A "blanket" of U-238 turns escaping neutrons back into the core; it also absorbs some neutrons and eventually becomes plutonium-239; hence, the name "breeder reactor.*" The Experimental Breeder Reactor II is of this design.

Intermediate Reactors. The large absorption probabilities of thorium in the intermediate energy range are used to improve the conversion of thorium-232 to uranium-233. An example is the molten salt reactor that uses thorium-232 in the "blanket" and produces fissionable uranium-233.

Plant Design

All reactor types follow a general design plan. Since metallic uranium burns in air and reacts with water, the fuel is contained in a compound which does not react with water, such as uranium oxides or carbides, in case of a water leak. Furthermore, the crystalline matrix more readily traps fission gases. The fuel is then encapsulated in tubes or rods which are arranged in bundles called fuel assemblies. Figure I-5 shows some typical fuel element designs. Several such assemblies are mounted in racks to form a reactor core. These form the second line of containment, the first line being the fuel matrix itself. The primary coolant is circulated in spaces between the tubes and around the assemblies. In the case of a thermal reactor, the coolant serves as a moderator to slow down the neutrons and as a coolant to carry away the heat (which produces the steam to run the turbines). In the fast reactors, little moderator capacity is needed.

The third line of containment is the reactor vessel, which is made of a high-integrity, stainless alloy. Sensing devices include temperature and pressure probes, neutron level and fission rate detectors, and period measuring probes, which check the rate at which reactor power changes.

The reactor vessel with its piping, wiring, and control mechanism is contained within a shielding enclosure. The enclosure is made of 6 to 8 ft-thick, high density concrete. The vessel, enclosure, and the canal which allows loading and unloading of fresh and spent fuel assemblies under water, is then enclosed in one (and sometimes two) additional enclosures designed to contain any release of radioactivity which might occur.

23

High-Temperature Gas-Cooled Reactor

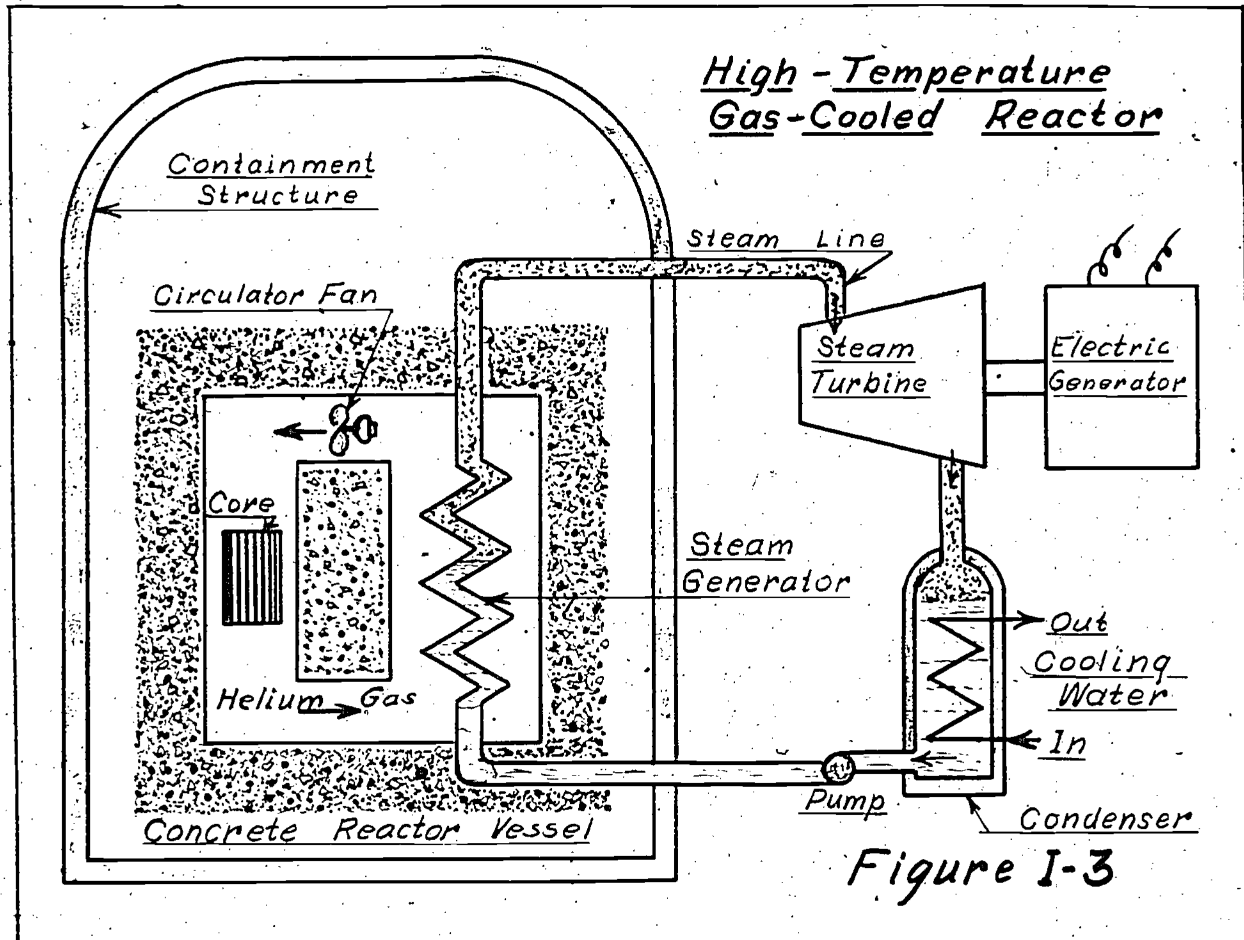


Figure I-3

Liquid Metal Fast Breeder Reactor

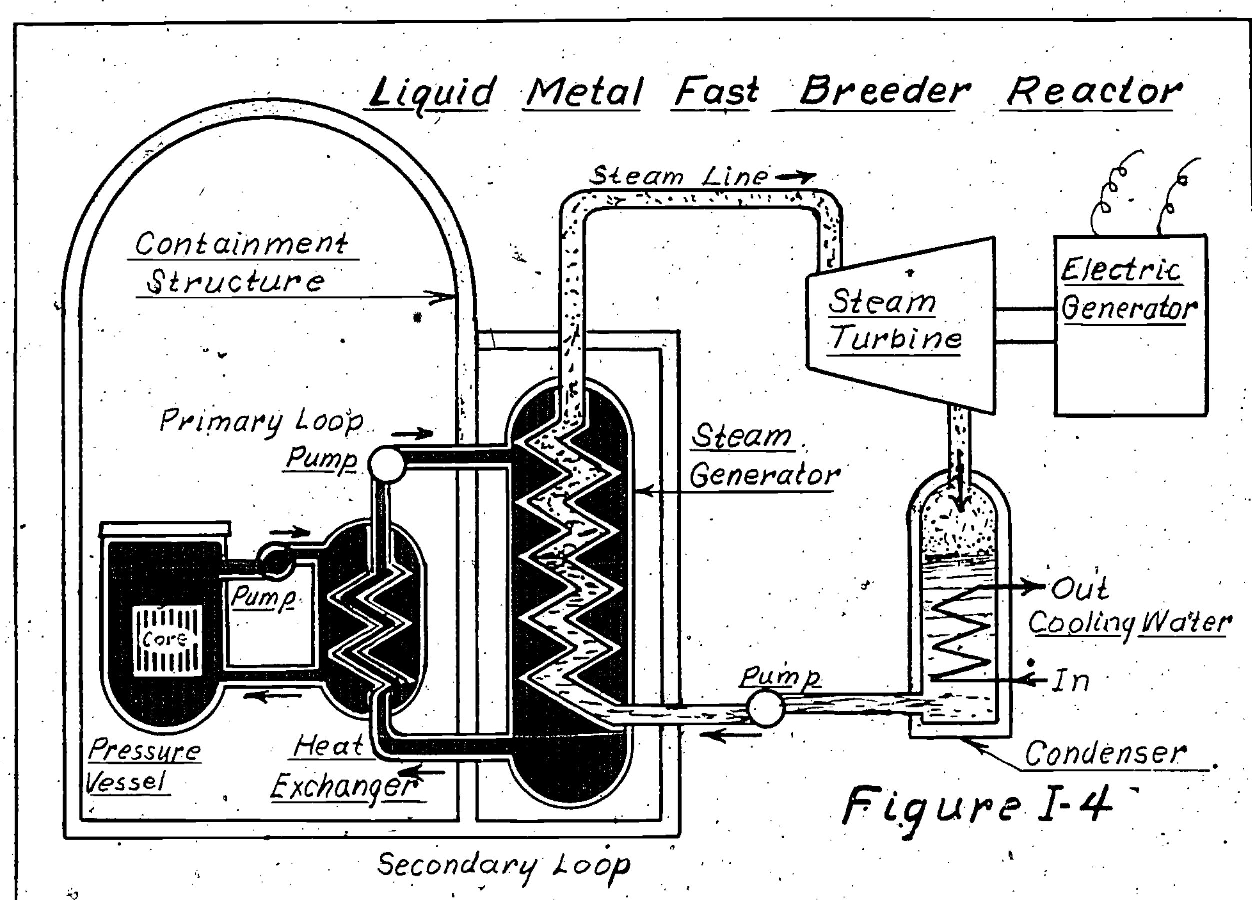


Figure I-4

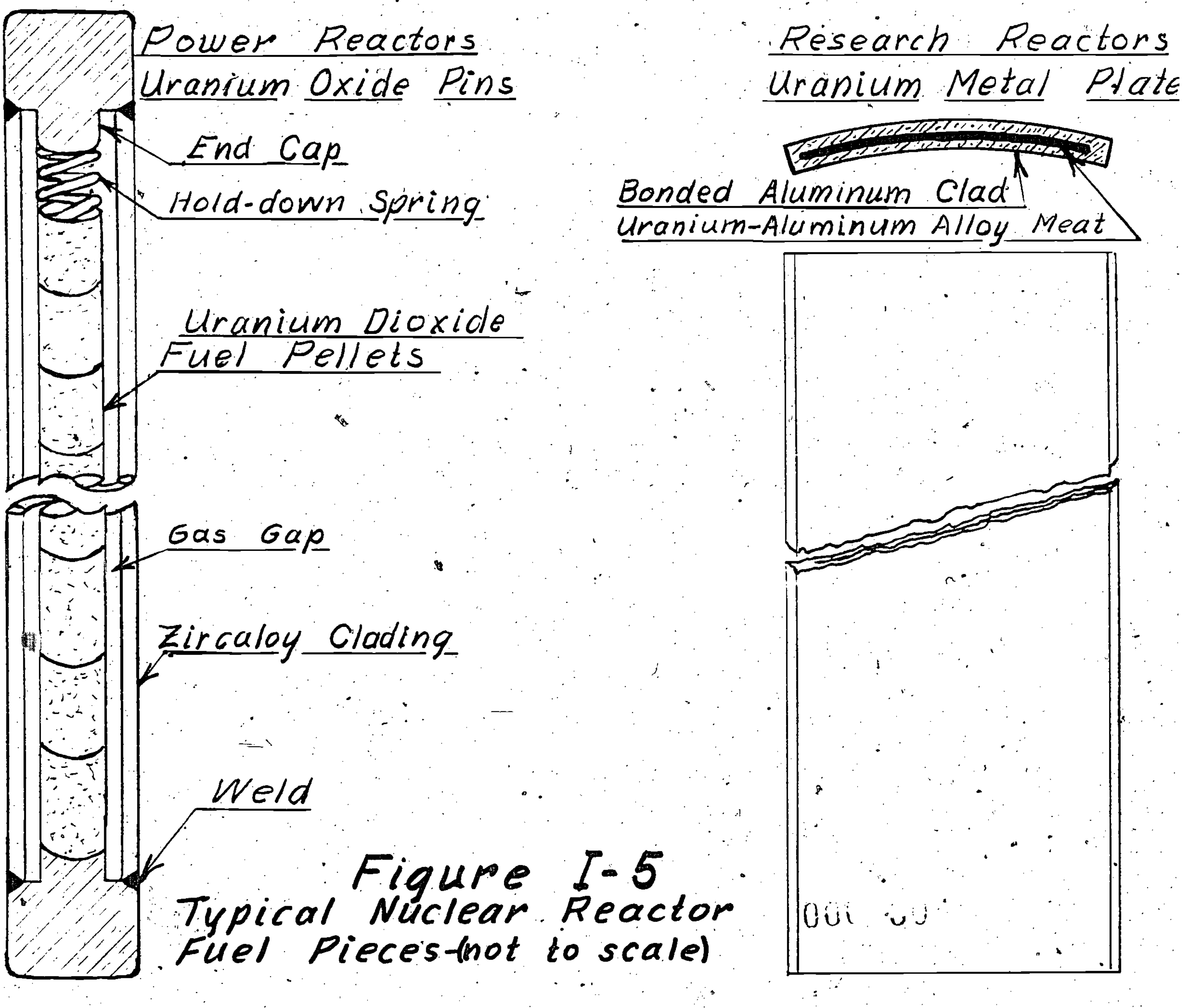


Figure I-5
Typical Nuclear Reactor Fuel Pieces (not to scale)

Waste Water is a problem with pressurized and boiling water reactors. Corrosion products and low-level radionuclides accumulate by neutron activation in the cooling water. Research is continuing into means of disposal which are environmentally, economically, and politically acceptable.

In a technological survey such as this, much detail has been sacrificed. The bibliography gives the inquiring reader a starting point for further information, if desired.

TECHNOLOGICAL UNIT QUESTIONS

These questions are not to be regarded as a test; rather, they are a part of the learning process. They are to be answered by reference to the text and glossary. The instructor will explain any questions concerning the correct answers.

1. Technological information is needed:

   a) To promote good will between industry and the general public
   b) To provide an understanding of the operation of a nuclear power plant
   c) To provide data on the cost of electricity
   d) To provide information on alternative energy sources

2. The word "materials" is understood to comprise:

   a) All physical masses, matter, i.e., the stuff the world is made of
   b) Only solid matter
   c) Only printed matter
   d) Composite collections of various atoms

3. The smallest particle of matter that retains the chemical properties of an element is called:

   a) A neutron
   b) An atom
   c) An electron
   d) A proton

4. Molecules are composed of:

   a) Small grains of material
   b) Protons and neutrons only
   c) Several electrons
   d) Two or more atoms of the same or different elements combined in definite proportions

5. The smallest particle of a compound that retains its physical and chemical properties is a (n):

   a) Molecule
   b) Atom
   c) Electron
   d) Element

6. Subatomic particles smaller than atoms are:

   a) Protons
   b) Neutrons
   c) Electrons
   d) All of the above

32

7. Nearly all of the mass of an atom is contained in:

a) The circulating electrons
b) The protons
c) The nucleus
d) None of the above

8. The nucleus is composed of:

a) Electrons and neutrons
b) Electrons and protons
c) Protons, or protons and neutrons
d) Protons, neutrons, and electrons

9. The number of circulating electrons in an atom is:

a) Equal to the protons and neutrons in the nucleus
b) Equal to the number of protons minus the number of neutrons in the nucleus
c) Equal to the number of protons in the nucleus
d) Equal to the number of neutrons in the nucleus

10. What characterizes the atoms of any particular element?

a) The number of protons in the nucleus
b) The number of neutrons in the nucleus
c) The number of electrons in the nucleus
d) The number of protons, neutrons, and electrons in the nucleus

11. An isotope of an element is:

a) An atom of that element with the same number of protons and a different number of neutrons in the nucleus
b) An atom of that element with different numbers of protons in the nucleus
c) An atom of that element with protons in the outer shell
d) An atom of that element with neutrons in the outer shell

12. Uranium-235, the fissionable isotope of uranium is present in natural uranium in the following percent:

a) 7.0%
b) 70.0%
c) 0.72%
d) 0.072%

13. The two most abundant elements in the earth are:

a) Oxygen and Aluminum
b) Oxygen and Silicon
c) Oxygen and Calcium
d) Oxygen and Magnesium

14. Radiation is a natural phenomenon used to:

a) Maintain the earth in its orbit around the sun
b) Produce ocean tides
c) Move energy from place to place
d) Prevent people from living excessively long lives

15. Familiar forms of electromagnetic radiation (EMR) are:

a) Heat and light
b) Radio and TV waves
c) X-rays
d) All of the above

16. The following are not EMR forms:

a) Alpha and beta rays
b) Heat and light
c) X-rays and gamma rays
d) None of the above

17. An atom that has lost an electron is said to be:

a) Agonized
b) Ionized
c) Publicized
d) Simonized

18. Ionization is harmful to humans because:

a) It lights up one's life
b) All atoms emit ionization
c) It is destructive of human tissue
d) None of its forms are directly observable by humans

19. Non-ionizing radiations can be harmful to humans because:

a) They have no practical value to humans
b) They are never visible
c) They are produced as products of radioactive disintegration
d) They are sometimes applied in excessively large amounts.

20. When an atom breaks up, the following radioactive disintegration products are formed:

a) Protons, neutrons, and electrons
b) Lexicons, croutons, and leprechauns
c) Hexagons, automatons, and xenons
d) Alpha, beta and gamma rays

21. Of the three products of radioactive disintegration, which is the most penetrating:

a) Gamma rays
b) Beta rays
c) Alpha rays
d) None of the above

22. Half-life refers to:

a) The time required for the break-up of a single atom
b) Half of the time during which an atom remains stable
c) The time during which one-half of the original quantity of an element is changed by radioactive disintegration
d) One-half of the average lifetime of an element

23. A short half-life means:

a) Many disintegrations in a short time
b) Many disintegrations in a long time
c) Few disintegrations in a short time
d) Few disintegrations in a long time

24. The least hazardous radioactive isotopes are:

a) Those having the shortest half-lives
b) Those having moderate half-lives
c) Those having the longest half-lives
d) None of the above

25. Assessment of the environmental effects of low-level radiation is made difficult if not impossible by:

a) Instrumental deficiencies
b) The pervasive nature of radiation
c) Interference from the earth's magnetic field
d) The existence of sun spots

26. An atom of Uranium-235 can be caused to split into two nearly equal parts:

a) By absorbing a neutron
b) By absorbing a proton
c) By absorbing an electron
d) By absorbing a photon

27. On the average, how many neutrons are emitted per fission in a nuclear reactor:

a) 2.5
b) 0.25
c) 25.00
d) 2.05

28. Neutron-absorbing material is added to the core of a reactor for the purpose of:

a) Absorbing heat for control purposes
b) Absorbing electrons for producing heat
c) Absorbing neutrons for control purposes
d) Absorbing stray protons

29. The energy produced in a nuclear reactor is:

a) The result of frictional forces
b) Due to hot spots on the Uranium-235 atoms
c) The result of the conversion of mass to energy
d) The result of cooling the core by circulating cold water

30. The fragments resulting from nuclear fission are known as:

a) Fission by-products
b) Electrons and protons
c) Stable isotopes
d) Unstable isotopes

31. The half-lives of fission products:

a) Are all very short
b) Are all very long
c) Have values ranging from very short to very long
d) Are all completely unknown

32. One cubic meter of calcined fission products produces enough gamma heat to heat:

a) 100 homes per year
b) 4 homes
c) Nothing at all
d) One mobile home

33. Strontium-90 is a dangerous fission product because:

a) It is soluble in water
b) It is soluble in Mazola Oil
c) It is radioactive and has a long half-life
d) It is radioactive; it displaces calcium in bones; it has a long half-life, and it has highly radioactive daughter products

34. When a fuel rod is removed from a commercial reactor as being used up (burned up):

a) It is thrown in the dump
b) Could be reprocessed to salvage the unused fuel and to remove the fission products
c) It is reprocessed to render the fission products harmless
d) It is reprocessed to make sure all the available heat has been extracted

38

35. A health physicist is:

a) A Physicist
b) A Technician
c) A Data Clerk
d) A watch dog
e) All of the above

36. A nuclear "bomb-like" explosion is impossible in a nuclear power reactor because:

a) Things like that just don't happen
b) Nuclear power reactors are constructed geometrically safe
c) Safety circuits have built-in devices to prevent explosions
d) Explosion-producing procedures are prohibited

37. A nuclear "bomb-like" explosion is:

a) One in which nuclear reactions only occur and temperatures and pressures result that approach those in the interior of the sun
b) One in which steam is produced as in a coal-fired plant
c) One that blows up like a bomb
d) One that has nothing to do with nuclear energy but is called that because of its violence

38. The event in Idaho was what kind of explosion:

a) A trivial matter
b) A "bomb-like" explosion
c) A steam explosion
d) An explosion that burst the containment building and spread radioactive contamination over a very large area

39. A recent event that has focused public attention on nuclear reactor safety was:

a) The sinking of the Titanic
b) The SL-1 reactor accident
c) The Three Mile Island accident
d) The bombing of Hiroshima

40. According to the findings of the President's Commission on the Three Mile Island accident:

a) There were equipment failures, but the incident would have been minor if properly handled
b) There was nothing the operators could have done to minimize the effects of the equipment failures
c) There were no problems with the equipment
d) The operators did everything possible to minimize the effects of equipment failures

41. The President's Commission is convinced that:

a) The operator's attitude toward reactor safety is of little consequence
b) Human beings who manage and operate the plants constitute an important safety system
c) Nothing more need be done to improve reactor safety
d) Regulations alone can assure the safe operation of nuclear reactors

42. The President's Commission believes:

a) That nuclear reactors are inherently safe and nothing more need be done
b) That it is an absorbing concern with safety that will bring about safety
c) That an absorbing concern with safety is desirable, but not necessary
d) That no amount of concern with safety will make nuclear reactors any safer

43. A vital component of the reactor safety system is:

a) A set of narrowly prescribed and complex regulations
b) A vast array of plant function indicators displaying normal operating conditions only
c) Well-marked escape routes for use in the event of an incident
d) The human beings who manage and operate the plant

44. The Naval Nuclear Propulsion Program has operated nuclear reactors how long without an accident involving a naval reactor:

a) 2.6 years
b) 26.0 years
c) 16.0 years
d) 1.6 years

45. A basic principle contributing to the safe operation of nuclear reactors is:

a) Total responsibility residing in one individual
b) High level of mental abilities and qualities of judgement
c) Strict compliance with detailed operating and casualty procedures
d) All of the above

46. Community officials need to take the following steps to assist industry to operate nuclear reactors safely:

a) Maintain a continuing expressed interest in plant safety operations
b) Leave everything up to the industry officials
c) Continue to pressure industry to adopt narrowly drawn, complicated regulations
d) Set up standards for industry to follow

47. The kind of a neutron needed to produce fissions in a pressurized water reactor is:

a) A fast neutron
b) An intermediate neutron
c) A thermal neutron
d) A fission neutron

48. Liquid sodium is used as a coolant in what kind of reactor:

a) Liquid metal fast breeder
b) Pressurized water reactor
c) Gas-cooled high temperature
d) Boiling water reactors

49. In a pressurized water reactor installation, light water is:

a) Never used
b) Used under pressure to prevent boiling
c) Used under reduced pressure to improve efficiency
d) Used mixed with liquid sodium to permit the development of high power

50. Oxides or carbides of uranium are used in preference to metallic uranium because:

a) Metallic uranium is pyrophoric (burns in the presence of air)
b) Fission gases are more readily trapped in the crystalline matrix
c) Does not react with water as does metallic uranium
d) All of the above

51. The most common commercial reactor types are:

a) Gas-cooled and Fast breeder reactors
b) BWR and PWR
c) Molten Salt and Gas-cooled
d) Fast breeder and PWR

52. The only device that is inherently safe to operate with little or no training is:

a) A nuclear reactor
b) A commercial jet-liner
c) An automobile
d) A paper airplane

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Public Affairs and Information Program
7101 Wisconsin Avenue
Washington, D. C. 20014

Edison Electric Institute
1111 19th St. N. W.
Washington, D. C. 20036

American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60525

General Electric Company
175 Curtner Avenue
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Sierra Club
530 Bush Street
San Francisco, California 94108

Technical Information Center
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Appendix T-1

Reactor Design Considerations

Geometrically Safe

The guarantee that a nuclear power reactor cannot explode "like a bomb" rests primarily on the concept of "geometric safety."

Neutrons emitted during fission have very high energies. Hence, the distance that they travel before encountering another uranium atom to produce another fission is also large. If, then, the distance from the site of the fission to the edge of the core is small compared to the neutron's path length, that neutron will escape before it can cause a fission. To maintain a chain reaction, at least one, on the average, of the average 2.5 fission neutrons must be absorbed by another uranium atom. If more than 1.5 neutrons per fission escape, the chain reaction cannot be maintained. That happens when the surface area of the core is large compared to the mass of the uranium. In the case of a bomb, this surface-to-mass ratio is reduced to the minimum. Nuclear power reactors have large surface-to-mass ratios to make them geometrically safe.

If the geometric factor were the only factor, there would be no nuclear reactors. At this point, other characteristics come into play.

Thermal Coefficient

The fission neutrons with low fission absorption probability must be slowed down to thermal energies where the fission probability is high. If, however, the core heats up, as it must to produce power, the neutrons are pushed up to higher energies where the fission probability is less. In addition, thermal expansion reduces fuel density and hence, fission probability. The degree to which the reactor responds to an increase in temperature is called the temperature coefficient. Most reactors are designed to have a negative temperature coefficient and hence, the power is self limiting. But there are other counteracting effects. Thermal expansion of the moderator and/or coolant, reduces neutron absorption and hence, neutron loss.

The above explanation has been over simplified and the actual design is much more complicated.

Reflectors

To maintain a neutron chain reaction, it is necessary to reduce the leakage of neutrons from the core. That is done by surrounding the core with a reflector. A reflector is a material having a large scattering probability and a small absorption probability. Various materials have been used for this purpose. Sometimes the reflector serves a dual purpose. When uranium-238 is used, it also serves as a breeding material; when graphite is used, it also serves as a moderator.

Delayed Neutrons

When nuclear fuel fissions, all the average 2.5 neutrons per fission are not emitted at the moment of fission. A small percentage are emitted from certain fission products a short time later. There are several groups of such delayed neutrons that are emitted anywhere from about .2 second to about 50 seconds following the instant of fission.

Delayed neutrons are crucial to the control of nuclear reactors. The power level of a nuclear reactor is controlled by the introduction or removal of absorbing or reflecting materials, that is accomplished by means of electro-mechanical devices.

The control circuits include neutron sensors, signal amplifiers, and mechanical actuators. These cannot be made to respond to neutron level changes instantly. The existence of these delayed neutrons, therefore, leaves time for the control devices to take effect.

The design of a nuclear reactor, therefore, requires an optimum balance of all these factors: fission probability of the nuclear fuel, neutron leakage from the core, reflector efficiency, moderator and coolant scattering and absorption probability, temperature coefficient, and control circuitry.

Appendix T-2

The Idaho Incident

Exactly what led to the Idaho incident referred to in the text, will never be known, since the three military service men present were killed. What is known is that steam was generated at such a rapid rate that the top of the reactor vessel was blown off, and the moderator-coolant and control rods were blown out of the core. Removal of the moderator put an end to the chain reaction and thus a "bomb-like" explosion was impossible. The chief damage to the core was mechanical, due to the violence of the steam explosion.

CITIZEN EDUCATION on NUCLEAR TECHNOLOGY

II - ENVIRONMENTAL/ECOLOGICAL UNIT

"And makes us rather bear those ills we have,
Than fly to others that we know not of."
Hamlet

INTRODUCTION

The relations between nuclear energy and the environment may be classified as, a) The effect of the environment on the nuclear power plant, and, b) The effect of the nuclear power plant on the environment. To place the whole question in the proper perspective, these same effects resulting from the construction of alternative energy sources also need to be considered.

The impact of the presence of a nuclear power plant on humans as a part of the eco-system is described.

As an example of the kinds of things that need to be considered, and how the problem was handled in one instance, the case of the Idaho National Engineering Laboratory in eastern Idaho is described.

ENVIRONMENTAL EFFECTS ON A NUCLEAR PLANT

Introduction

When planning for a nuclear power plant begins, the plant's effect on the environment and the environment's effect on the plant are among many factors considered. The intent is to minimize, to the greatest extent possible, any damage which may occur in the event of an accident.

The siting of the plant, therefore, considers such things as prevailing wind directions, rainfall history, and flood threats, and the seismic (earthquake) characteristics of the area.

The wind direction is probably the most obvious concern to the layman. If an accidental release of radioactivity were to occur, it would be important that the plant be sited to minimize the effect of that radioactivity, particularly on people and in agricultural areas.

Rainfall and flood threats from nearby rivers or dams are also considered because of their possible impact on the plant structure itself.

Most people, when they think of earthquakes, think of an earthquake belt, stretching from California to Alaska. Many also remember the quake which struck the Yellowstone Park area in 1959. People who live away from those areas probably think of earthquakes as something which "can't happen here."

Actually, every area of the U. S. is subjected to small tremors as a normal occurrence, usually unnoticeable except on specialized equipment. In fact, Boston, Charleston, S. C., and the St. Louis area have all suffered massive quakes since they were settled by European colonists. Since this potential exists, the builders of nuclear plants are required to prepare for that remote worst possible event.

This part of the text will deal with conditions that exist in the area of the nuclear test facility here in Idaho. The material is presented as an example of the kinds of things that need to be considered in the construction of commercial nuclear power plants.

Prevailing Winds

The Idaho National Engineering Laboratory is in a belt of prevailing westerly winds. Lack of atmospheric stability in the spring and summer leads to stronger winds, with the highest wind speeds registered in the spring.

Generally, wind direction is governed by the mountains and mountain/valley effects, with alterations caused by storm patterns. At higher altitudes, the predominant direction in the winter is NW, shifting to W in the spring, SW in the summer, and back to NW in the fall.

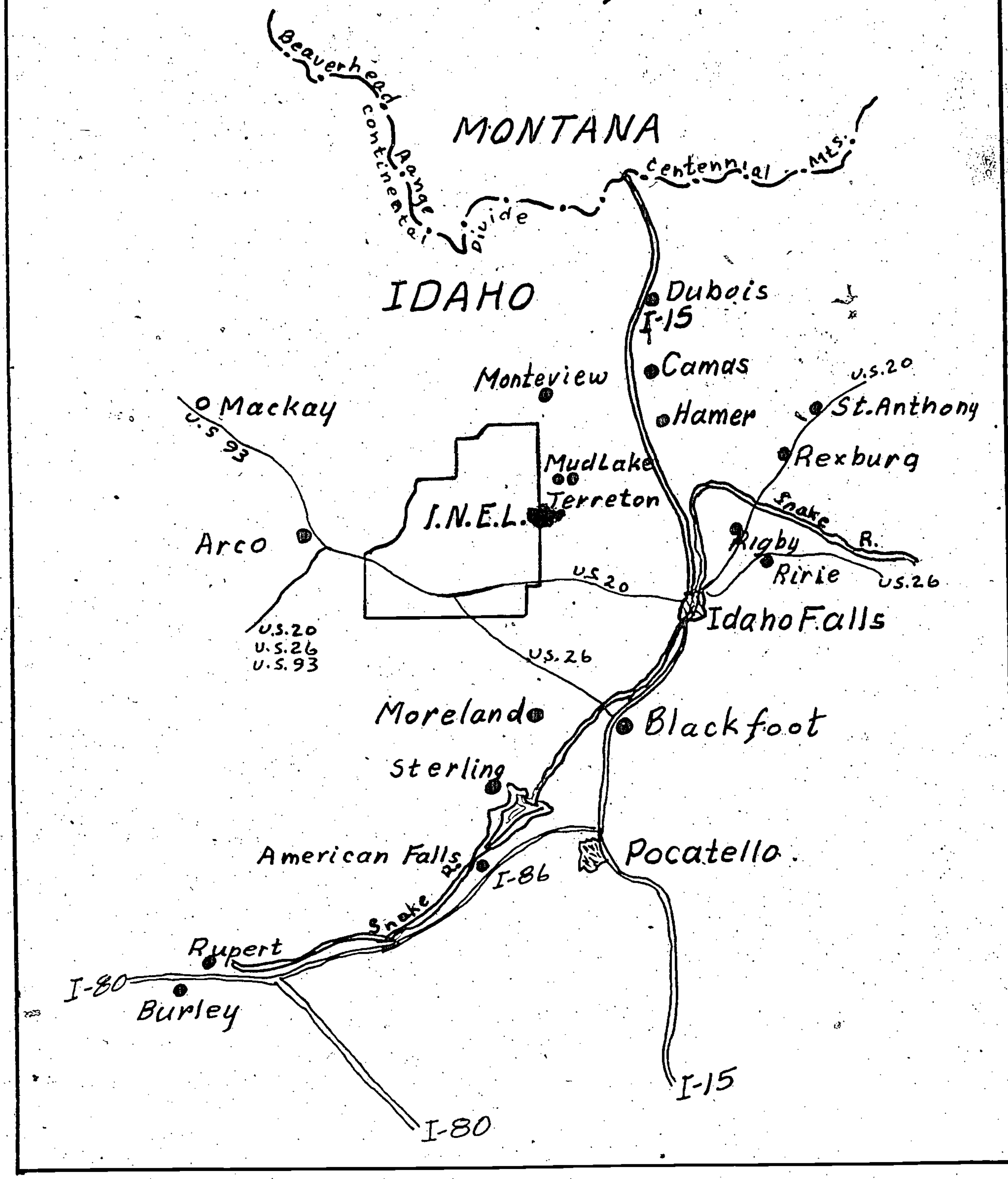
Information about wind speed and direction is derived in three ways: radar; transponders - a radio device sent aloft in a balloon which transmits weather information at the command of a base station; and tetroons - a one-cubic meter four-sided constant volume balloon made of mylar.

The primary concern, for this course, is the relation of wind direction to population centers. Towns in the path of southwesterly spring and summer winds include Monteview, Mud Lake, Terreton, Dubois, Camas, Hamer, and St. Anthony. In the winter, strong southwesterly flows can occur in advance of a storm front. The normal northerly winds of winter flow toward Arco, Sterling, Pocatello, Moreland, and Taber. (See Figure II-1)

Flood Threats

The United States Geological Survey (USGS) has completed three surveys to evaluate the effects of floods and dam failures on INEL facilities. The objective in each was to calculate the route and volume of flood waves from Mackay Dam, in case of a failure, or routes of 300-year snowmelt floods on the Big Lost River. (Floods are categorized by their severity. A 300-year flood, therefore, is one so severe that the chance of its occurring is only once in a 300-year period.) See Figure II-2)

Figure II-1
I.N.E.L. and Vicinity



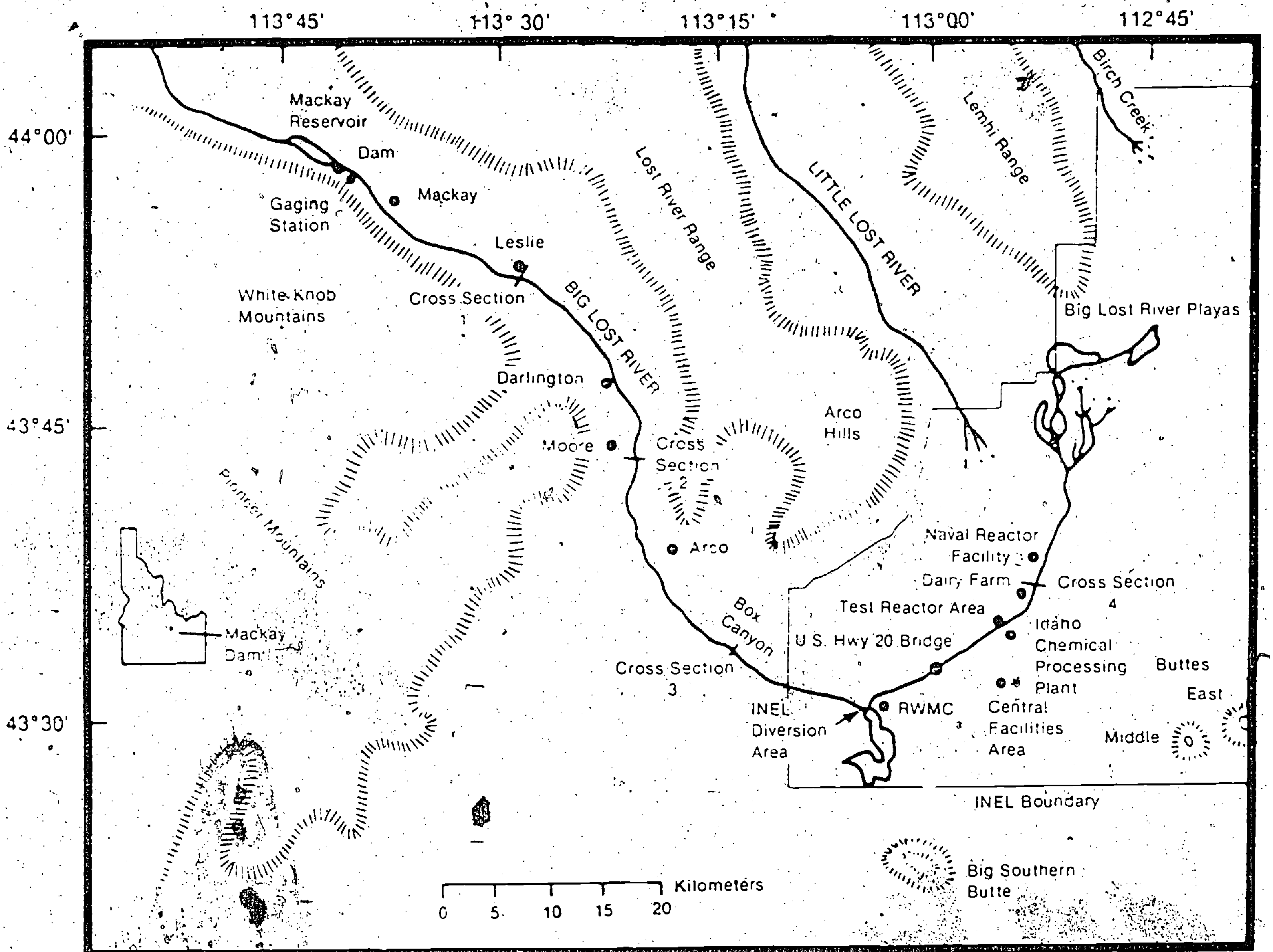


Figure II-2 Location of sites in the Big Lost River basin downstream from Mackay Reservoir.

Source: Probable Hydrologic Effects of a Hypothetical Failure of Mackay Dam on the Big Lost River Valley from Mackay, Idaho, to the Idaho National Engineering Laboratory, IDO-22058, U.S. Geological Survey, (September, 1979).

The flood plain on the INEL Site is very flat and ranges up to five miles wide. Facilities which may be threatened by severe flooding include the Radioactive Waste Management Complex, State Highway 20, Central Facilities Area, Test Reactor Area, Idaho Chemical Processing Plant, and the Naval Reactor Facility. These range 49 to 62 miles from the dam site.

Stream flow in the Big Lost River originates in mountains to the north and west of the Site. Because of water storage at the Mackay Reservoir and reduced stream flow due to irrigation diversions and infiltration along the river, significant amounts of water in the Big Lost River within the INEL occur only when there is an abnormally large snow melt.

Flows on the river system within the Site are separated at a diversion dam, in the southwest corner of the Site. Four natural depressions are used as "spreading areas" and the diverted waters are allowed to naturally infiltrate. Since the flood control project was constructed in 1958, no water has reached the fourth spreading area and only a small amount reached the third area, in 1965.

The water which remains in the river channel is reduced by infiltration. About 18 miles beyond the diversion dam, the water enters an area of branching channels and four playas (flat-floored, undrained desert basins which become shallow lakes). Again, some water has reached the third playa and none has reached the fourth.

Seismic Effects

A two-year microseism study for the Eastern Snake River Plain area was completed in 1976. The study was prepared by the Health Services Laboratory at the INEL and the U. S. Geological Survey office in Las Vegas, Nevada.

Three stations at the INEL and three at Teton Dam were operated daily during the study (January,1974-December, 1976). In that time, 8700 natural earthquakes were registered at the six stations, with none above 1.5 magnitude on the eastern Snake River Plain and none near the Teton Dam reservoir. In that period, no earthquakes were detected on the INEL.

There has been no history of damage to buildings in the area occupied by the INEL. The Hebgen Lake earthquake, August 17, 1959, which measured 7.1 on the Richter scale, only resulted in the splashing of some water from a reactor storage canal.

Through 1969, the eastern Snake River Plain was designated a zone 2 seismic risk value, or moderate damage probability. In 1969, this was changed to zone 3 - major damage probability. There is currently discussion that may result in a return to the zone 2 ranking. (Earthquake zone rankings are assigned by the International Conference of Building Officials.)

Other studies have shown the potential for earthquakes at the INEL focuses in two areas. The first, a scarp (line of cliffs caused by fracturing of the earth's crust) across from Howe, Idaho, is considered a site of potential concern to the INEL. The second, a scarp on the east side of the Big Lost River Valley north of Arco, was identified for further study. Both faults may have been active as recently as 4000 years ago, and a magnitude 7.1 quake may have occurred at each location. Neither the Arco nor the Howe scarp showed any activity during the 1974-76 study.

The art of designing structures to withstand earthquakes has made significant progress in this century. This progress has been applied to the planning for earthquake-proof power plants. Three large industrial and conventional power plants which have been designed to withstand and have been subjected to large earthquakes, have experienced no major damages. There has been little actual experience with earthquakes at nuclear power plants. Those that have occurred (minor quakes in Japan, two major quakes in California) have caused no damage.

Planning for nuclear power plants is required to include provisions for siting and construction which would minimize exposure to active faults and damage, should tremors occur. Vibration tests are conducted on individual components and entire reactor buildings have been tested, using mechanical shakers. High explosive charges have also been detonated nearby to simulate the effect of strong tremors.

EXTERNAL EFFECTS OF NUCLEAR POWER PLANTS

Introduction

Under normal operating conditions, nuclear reactors have a potential for easing some of our environmental problems. They do not cause the air pollution which is a problem with fossil-fueled plants. And, since so much less uranium than coal is needed (65 tons of uranium ore vs. 2,500,000 tons of coal for a 1000 MW plant annually), there would be proportionately less land damaged through strip mining, etc. The sheer volume of waste material at the power plant site is much less, with coal waste running about 12% of the total burned (12 tons of ash for every 100 tons burned) and nuclear at about .004% (eight pounds per 100 tons of uranium ore mined). To be fair, uranium ore processing results in large amounts of waste. Generally, the ore is milled at or near the mine site, with solid waste returned as part of the site restoration process. The coal waste described above is produced at the site of the power plant, rather than at the mine.

The majority of thermal power plants (both fossil and nuclear) discharge condenser cooling water directly into nearby waterways. In many areas, damage has been done to streams and tidal basins. As new ecological studies are completed, existing state, regional, and federal standards will probably become even more rigid.

Limited benefits of this waste heat may be in agriculture and aquaculture, but extensive use is a long way down the road, with much research still to be completed.

The immediate environmental concern which must be resolved if nuclear energy is to assume a greater proportion of the burden in this country, is the disposal of radioactive waste materials. The processes currently used are described later in this unit.

Radiological Release

Two kinds of biological effects exist. Somatic effects are those experienced by the thing exposed to radiation. Genetic effects are those which are passed on to succeeding generations. It is assumed that the effects of radiation are proportional to the amount of exposure. There is no evidence that low levels of radiation cause either effect, but it is also assumed that there is no "safe" level. Therefore, very strict regulations are in place for the operation of nuclear power plants.

Continuous studies of the environment are a condition placed on the utility when an operating license is issued. The kinds of controlled releases of gases and water which occur under normal operating conditions are tiny fractions of the conservative limits set by the federal government. Some plant and animal species "reconcentrate" radioactive materials in their systems without doing harm to themselves. Some shell fish and aquatic plants are such life forms. These are used as monitors.

A legitimate area of concern for many scientists is the cumulative effect. Many studies and experiments have been conducted and papers written about the effects of unusual doses of radiation. Subjects have either been exposed during controlled experiments or as a result of fallout from nuclear weapons tests, because the area around nuclear reactors simply doesn't contain excessive amounts of radiation.

Radiation Effects

Before describing radiation effects, it is necessary to define the units being used. Radiation sources are measured in terms of a unit called a Roentgen, named after Wilhelm Roentgen, the discoverer of X-rays. It is based on the amount of energy in the form of ionized particles appearing in a cubic centimeter of air under standard conditions of pressure and temperature.

A difficulty arises when applied to humans, since the energy absorbed by human tissue is different than that absorbed by air for the same gamma (or X) ray. The problem was solved by relating the radiation dosage to the amount of biological damage. The new unit is called a roentgen equivalent man (rem).

Human Effects - The principal route of external contamination for the general population would be from radioactive gases. The result of large amounts of such gases can be death from radiation poisoning or the possibility of leukemia or other cancers. These diseases arise from other causes as well, of course, and are difficult to pin to specific causes. Other cancer agents, including food additives, pesticides, combustion emissions, etc., are also difficult to isolate.

Lesser dosages result in symptoms such as nausea, vomiting, and lassitude for several weeks before full recovery.

The most talked-about incident of accidental release is, of course, Three Mile Island in March, 1979. Studies were immediately undertaken to determine the effects (most of the gases were contained). It was estimated that any increase of cancer, if indeed there is any increase, will be so small as to be impossible to detect from the number of cases which can be expected anyway. The most serious health effect, according to the Kemeny report, was mental stress.

Table II-1, taken from Nuclear Power Quick Reference (General Electric Corporation, using material from Background Information of Radiation by R. E. Linneman, M. D., April 4, 1979) lists sources of natural and man-made radiation.

Table II-1

Natural Background Radiation

Source	Millrem Per Year
Cosmic Rays	35
Air	5
Building Materials	34
Food	25
Ground	11
Total:	110 mrem

Man-made Radiation

Source	Dose Rate
Coast-to-Coast jet flight	5 mrem/round trip
Color television	2 mrem/year/hour of viewing
X-ray diagnosis	50 mrem/exposure
Weapons fallout	4 mrem/year
Living within a 50-mile radius of a nuclear plant	.02 mrem/year

Table II-2 lists the effects of ionizing radiation on humans.

Table II-2

Radiation Effects on Humans

Dosage (in a few minutes*)	Effects	Result
200 rem	nausea, vomiting, diarrhea, irritable lassitude	full recovery in 1-2 weeks
500 rem	same symptoms in more acute form	1/2 of those exposed will die in 30-40 days; other half-full recovery in several months
1000 rem	fatal to all	larger the dose, the sooner the fatality

*Similar dosages spread over a longer period (say, one year) would produce no symptoms, no fatalities.

Source: The National Council on Radiation Protection and Measurements

Federal standards for workers at nuclear power plants limit dosage to 5 rem per year, and the general public to 0.17 rem per year. The average exposure is less than 0.8 rem throughout the industry, and 0.001 rem for individuals living near nuclear power plants.

Radiation standards are based on 50 years of research by the International Commission of Radiological Protection and the National Council on Radiation Protection and Measurements.

An estimate of your personal exposure to natural and man-made radiations can be calculated by use of Table II-1. Table II-3 is a form that you can fill out to make that calculation. Under "Location," Idaho Falls residents add 47. Add the appropriate number for the type of house you live in. Add appropriate amounts for jet-air travel, television viewing, X-ray diagnosis, and proximity to a nuclear plant. By studying the entries in Table II-2, you can determine what steps you might take to reduce your annual exposure.

Table II-3

Human Effects - Radiation

How to Estimate Your Radiation Exposure

Radiation Source	Annual Exposure
Location: Cosmic Rad. at Sea Level plus 1 x each 100 ft. of elev. (Idaho Falls - 4700 feet)	35 mrem
House Construction: Wood - 35, Concrete - 50, Brick - 75, Stone - 70	
Ground: U. S. Average	11
Water, Food and Air: U. S. Average	25
Jet Travel: Number of 6000 mile flights (round trip, coast to coast) x 4	
Television Viewing: Black and White - number of hours per day x 1	
Color - number of hours per day x 2	
X-ray diagnosis and treatment:	
Chest X-ray - number x 50	
Gastrointestinal - number x 2000	
Dental - number x 20	
Sub-total:	mrem
Proximity to nuclear power plant:	
At boundary - number of hours per day x 0.2	
One mile away - number of hours per day x 0.02	
Five miles away - number of hours per day x 0.002	
Over five miles - None	
Total:	mrem

(Source: United States Energy Data Book, 1979, The Institute of Electrical and Electronic Engineers, Inc.)

Table II-4 lists the life-shortening effect of various factors in human experience.

Table II-4

Life-Shortening Effects of Various Factors in Human Experience

Factors Tending to Decrease Average Lifetime	Decrease of Average Lifetime
Overweight by 25%	3.6 years
Smoking 1 pack per day	7.0 years
Smoking 2 packs per day	10.0 years
City rather than country living	5.0 years
Actual radiation from nuclear power plants in 1970	less than 1 minute
Estimate for year 2000 with 100-fold increase in nuclear power production	less than 30 minutes

Source: Advisory Commission on the Biological Effects of Radiation, National Research Council, 1972.

For those who might be interested in the effects of extreme doses of radiation, there are several publications available.

1. Some Effects of Ionizing Radiation on Human Beings - a study prepared by the Naval Medical Research Institute, the U. S. Naval Radiological Defense Laboratory and Brookhaven National Laboratory. A report of work done following exposure to fallout from a nuclear weapons test in the Pacific in 1954.

2. Long-Term Effects of Ionizing Radiations from External Sources - a report prepared by a Subcommittee of the Committee on Pathologic Effects of Atomic Radiation of the National Academy of Sciences - National Research Council.

3. A summary of studies done in two cases of extensive radiation exposure due to fallout from a nuclear weapons test in 1954 is contained in Environmental Radioactivity, by Merrill Eisenbud.

Health Effects on Miners of Uranium Ore

During the early years of the nuclear industry, only general protection requirements were enforced. In 1966, however, the Federal Metal and Non-Metallic Mine Safety Act was passed to limit exposure to hazardous materials. This was further amended in 1971, including better ventilation of mines. All aspects of the nuclear power industry results in three cancer deaths per year, according to figures available from the National Institute for Occupational Safety and Health.

Flora and Fauna Effects

Studies have shown that controlled releases of radioactivity have been of no ecological significance. Less complex organisms seem to be more resistant to the effects of radiation. Deserts, tundra, and grasslands seem to be most resistant to the effects of larger doses of radiation, followed by deciduous forests, with coniferous forests most sensitive. This is true of aquatic life forms, as well.

In case of accidental releases of large amounts of radioactivity, damage to an agricultural area would be of the most concern, because of entry into the food system.

In 1957, a significant release of radioactivity occurred at Windscale in England. Prompt reaction by authorities, principally through the collection of contaminated milk before it reached the public, allowed the Medical Research Council to say that it was highly unlikely that anyone had been harmed. (The Windscale facility accident occurred with an unshielded production reactor - a condition which does not exist in commercial facilities.)

The Yankee Atomic nuclear power plant at Rowe, Massachusetts, has operated since 1961, with no damage to flora and fauna. Extensive tests have been done and veterinarians in the area have been on the alert for any reaction in animals.

Waste Disposal

Nuclear fuel is not a significant radiation hazard until it has been used in a reactor. Currently, fuel rods are stored at the reactor site after use. Originally, reprocessing plants were to separate the plutonium and uranium from the spent fuel rods, shipping the fission products to waste depositories and returning the uranium to the refinery to be prepared for use again in fuel rods. Reprocessing plants planned to receive original shipments from utilities in 1983.

Since the late 70's, however, reprocessing has not been considered an option in this country and the utilities continue to store spent fuel rods in water baths at the reactor site. Radioactive decay continues during this time.

Several reasons, both political and economic, have contributed to the decision not to reprocess spent fuel rods. The political reasons include fear of proliferation to non-nuclear countries of the ability to make nuclear weapons and the chance that terrorists may try to obtain the material for blackmail or other reasons. The economic reasons include an estimate, by the Nuclear Regulatory Commission, that the cost of building and operating the reprocessing plants would be so high that fuel cost savings to power users would be in the range of 1%. Of course, uranium is a finite substance, and as supplies of uranium become less available, the economic need for reprocessing will become greater.

Other solid waste materials (protective clothing, tools, equipment, piping, etc.) are shipped to repositories. They are put into "plastic" sacks, then into steel drums, then sealed for shipment in steel containers which have met rigid specifications.

Tests of these containers have been devised to insure that no radiation could escape if there were a truck or train accident during shipment. Tests have included dropping the container 30 feet to a hard surface; exposure to 1475° fire for 30 minutes; total immersion for at least 8 hours; and, atop a railroad flatcar, ramming into a concrete wall at 80 mph.

There have been no injuries or deaths due to the radioactive materials being transported. There have been some driver injuries or deaths in accidents involving trucks carrying nuclear materials, but there was no release of contaminated materials in these cases.

Any damage which might occur during shipment is covered under the provisions of the Price-Anderson Act.

The fixation of fission by-products in a pyrex-type glass has been known for ten years, but recent research has shown that at temperatures above 300° C some fission products escape. Current research is under way to develop crystalline mineral forms that have geometric structures compatable with the crystal structure of the fission products themselves. In that way, the fission products and the host matrix will be more firmly bonded and the escape likelihood reduced, or it is hoped that escape will be eliminated.

The use of glass-sealed fission products for low-potential space heating, as indicated in the section on Fission Products in the Technology Unit, would tend to keep the temperature of such units well below the 300° C level.

EFFECTS OF POWER PLANTS IN GENERAL

Introduction

With a burgeoning population and increasing industrialization, the world's decisions about energy production are becoming more and more critical. An important but little understood facet of energy production is its effect on the world's climate and environment. This material will consider some problems which occur with other energy sources, as well as the impact of nuclear power plants on the environment. The subject is so vast that no workshop format can adequately cover the material. We hope the workshop participant will gain a realization that there are no simple answers to the energy dilemma.

Fossil Fuels

Over 97% of the industrialized world's energy demand is satisfied by the burning of fossil fuels. It has been estimated that, even with conversion to alternate sources, use of fossil fuels will double by the year 2000.

Fossil fuels emit sulfur dioxide and oxides of nitrogen which are carried in the air for 1-4 days, drifting 150-1000 miles. Eventually, the pollutants fall to earth again as acid rain.

Acid rain pollutes water and reduces fish capacity to reproduce, resulting in smaller and older populations which finally disappear. Hundreds of lakes in the Adirondacks are no longer able to sustain trout populations.

In human habitats, effects of acid rain are observable. Two town water systems near the Adirondacks have lead levels 5 times the EPA maximum, because acid rain water leaches lead from the solder of municipal water pipes.

Scrubbers could eliminate as much as 97% of the offending material. Estimates have been made that, even if industry were to begin a program tomorrow of seriously addressing the problem, it would take 15 years to reduce the pollution to present levels, because pollution by coal is increasing more rapidly than scrubbers can be installed.

For many scientists, the increased amounts of carbon dioxide in the atmosphere is a greater concern. Simply put, carbon dioxide slows down the radiation of heat from the earth's surface into space. This has become popularly known as the "greenhouse effect*." Warming of the atmosphere could result in shifts of agricultural zones, less sea ice, a higher sea level, shifts of marine ecosystems, and a flux of carbon dioxide from the ocean to the atmosphere (thus aggravating the situation).

Radioactive Release - Coal

Coal contains materials such as potassium, thorium, and uranium, which are radioactive. A 1000 mW (mega Watt*; million Watts) coal-fired plant, burning 10,000 tons of coal per day, releases about 100 lbs. of radioactive material per day. While most of this is contained in unburned particulates* and ash, some is released as gas into the atmosphere. The result is that many coal-fired plants release more radioactivity than nuclear plants. These amounts are still below proscribed radiation levels and no environmental damage has been detected. Currently, no efforts are being made to control such releases.

Synthetic Fuels

Synthetic fuel research has increased greatly in the last few years. Techniques include coal gasification* and coal liquification.*

The most serious problem for large scale conversion of coal to synthetic fuels is the need for water, both for cooling and as a raw material. This is intensified because most of the coal to be used is located in dry western states.

Since the agriculture of this region requires water for irrigation and some of the fastest growing cities in the country are also in this area, the competition for water is already severe. A new competitor, in the form of new energy industries, will clash with these other water users. The political and economic consequences are obvious.

An example of the political consequences which may be expected occurred in January, 1980, when Senator Church of Idaho introduced legislation to stop the EPA from studying the possibility of diverting water from the Northwest to the Southwest.

Large amounts of solid waste would remain, which may be returned to the mining site, and there would be significant air pollution requiring scrubbers for particulates and SO_2. Another significant problem, environmentally and economically, is the lack of water in the western states to reclaim the land after strip mining.

Solar

Huge amounts of land would be required for large scale generation of electricity from the sun. Estimates of the land needed to generate the amount of electricity to be produced by existing and proposed nuclear power plants in the year 2000, are for an area the size of West Virginia. Of course, part of the solution would be to use the tops of buildings, but large land areas will still be required.

Collecting panels will affect surface absorption and evaporation, temperature and wind pattern; whether that influence will be beneficial or harmful is an unknown. Another unknown is the cost to the environment of production of silicon in the amounts needed.

Other environmental problems to be solved include the effects of silicate particles, sulfur and arsenic on the atmosphere. If heat transfer solar units are used, miles of tubing containing freon, liquid metal, ethylene glycol, or other medium will be needed. The danger of a spill must be reckoned with.

Note Added in Proof:

A recent publication of the Electric Power Research Institute (EPRI Journal for June, 1980, P. O. Box 10412, Palo Alto, California, 94303) contains an updated account of what happened at Three Mile Island. To quote from that article,

"There is a pressing need...to update earlier accounts that were often spotty, inaccurate, or incomplete. In this issue, the EPRI Journal takes a comprehensive look at the accident,..."

It is strongly recommended that a copy of this publication be placed in every public library, to the end that the public might avail themselves of a factual account of that incident.

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CITIZEN EDUCATION on NUCLEAR TECHNOLOGY

III - SOCIOLOGICAL UNIT

"...adventurous souls with a high tolerance for ambiguity..."

Malcolm S. Knowles
The Modern Practice of Adult Education

INTRODUCTION

The Sociological Unit considers four aspects of the impact of nuclear power on a community.

Community attitudes are approached by means of questionnaires and the attendant analyses. Community preparedness deals with the ability of the community to handle demographic changes resulting from the construction and operation of a nuclear power plant. The disaster aspect of preparedness is integrated with the local Civil Defense agency. A community education program is described for use of workshop participants. Community use of energy analyzes the result of replacing fossil fuels with nuclear energy in the generation of electricity.

COMMUNITY ATTITUDES

Public attitudes are formed by a variety of forces: early training and upbringing, peer pressures, public and private educational exposures, personal involvement, and a vast array of sources known collectively as the "mass media." Thus, it is of interest to discover not simply what the attitudes are, but in addition, the origin of those attitudes. Since the participants of this workshop cannot be expected to have either the time or the inclination to conduct an adequate community-wide survey, the question of attitudes will be confined to the workshop members. Questionnaires designed to assess their current opinions will be used.

Procedures

The current attitudes of the workshop participants are assessed by means of questionnaires. One is to be filled out at the beginning of the course, and another at its completion. The results then serve the dual purpose of assessing the attitudes of the participants and of evaluating the effectiveness of the course material. The initial questionnaire is given in Appendix S-1.

You will find a number on the inside of the cover of your text. This number is to be used when answering the questions on both pre- and post-questionnaires. This procedure has been adopted to permit a pre- and post-evaluation of attitudes while keeping the identity of the respondents anonymous.

Decisions concerning the development of alternative energy sources involve an evaluation of the relative risks. The role of risk in such decisions is therefore of interest as one factor contributing to the formation of community attitudes. The Risk Game has been devised to evaluate this factor. The game will be conducted by the instructor. (See Appendix S-2)

COMMUNITY PREPAREDNESS

Social Readiness refers to the ability of a community to cope with situations resulting from large and/or sudden changes in population; availability and distribution of housing, adequacy of schools, demands on entertainment and recreational facilities, crime control, alteration in traffic patterns, and changes in cultural patterns. All of those areas have their attendant fiscal effects; housing shortages push up prices; the need for additional crime control facilities and more educational facilities requires the spending of additional public funds.

All these problems are aggravated by the time scale involved. During construction, one can expect an influx of population. The inflated population might last as long as five to ten years. With full operation, the labor needs drop and population drops, but not to the original level. The magnitude and duration of these changes need to be anticipated and provision made to minimize the resulting social dislocations.

Construction of a Nuclear Facility and Its Impact on the Community

In the case of Idaho Falls and the surrounding area, judgements of impact are difficult to make. Because the Idaho National Engineering Laboratory has been in place for so long, and because expansion and new programs are occurring on a continuing basis, the sociological impact has become constant.

Certainly, numbers are available. Approximately 10,000 people are directly employed by the Department of Energy and its contractors. Multiply this by family size and it is easy to see that significant portions of Idaho Falls and surrounding towns are here because of the site.

The effects this large group of people have had on the area have been mixed, though generally regarded as favorable by the community. Employees and their families have been active in such areas as education, civic affairs, cultural programs, etc. They have also been the source of much of the growth in housing and commerce in the area with all that means to the beholder.

They have not resulted in the boom town syndrome, because of the constancy of the Site programs. This makes the Idaho Falls circumstance very different from that of a town constructing a commercial nuclear power plant.

Energy Boom Towns

In 1976, John Gilmore, of the University of Denver, conducted a study of the impact of energy resource development on Western towns.(7) Western towns are unique because of the distances which separate concentrations of population. These distances force a town to rely on its own resources during a boom period.

His study considered primarily those towns which would experience a rapid surge in population, but which would retain that increased population for a long period of time. For example, a town could be the source of a large-scale coal mining operation and a 1000 mW coal-fired generating plant. In the case of a nuclear plant, the increase in population is generally only during the construction period (a minimum of 10 years). In some ways, this "long-term-but-temporary" may even aggravate the problems found in the Gilmore study.

He found that boom towns experience breakdowns in the labor market, housing, financing of public facilities; that education and health services and housing lagged far behind the demand. Mental health clinic caseloads increased, particularly due to problems of trailer-bound wives of newly arrived workers. Within the established population, there are also problems, including a tripling of the high school drop-out rate and increased employee turnover rate in existing industry.

Gilmore identified four phases of attitude among local elected officials and much of the public. In the beginning, enthusiasm - as they anticipate the economic growth in their community; next, uncertainty - as they consider the demands that will be made on existing public services; then, near panic - as they realize the gap between prospective revenues and prospective expenditures; finally, problem solving. The more information about the problems and changes to be expected, and the earlier that information is available, the sooner the last phase occurs.

Many people will be interested in the decisions the town makes, including industry, land speculators, the media, consultants, researchers, and state and federal agencies. Because of the temporary nature of the construction phase, private investors may be reluctant to invest in housing, commercial buildings, etc. For the same reason, local government may be unwilling to finance schools, roads, and other public facilities.

The town officials and the residents must be willing to deal with the problems and control the responses if they are to be resolved. Gilmore identified a number of tools which the community may employ:

1. Holding down basic investment through legislative control of plant sites

2. Requirement of off-site investment by incoming industry to assure provision of basic services

3. Subsidies to communities, just as the industry may be subsidized

4. Zoning

5. Use of federal lands for temporary housing

6. Preference in hiring to area residents, including training and retraining programs

7. Early identification of community priorities in terms of housing, health services, road and street maintenance, sanitation services, schools and shopping

Government Programs

A program to assist energy boom towns through the Economic Development Administration was proposed but never enacted. There is a Farm Home Program for coal mining/power generation impacts.

Conclusion

Any town facing the problems of rapid growth must realize the importance of recognizing and dealing with those problems early. Working with the incoming industry, setting priorities and making decisions openly can cushion the impacts. The roles of elected officials, the media, and the general public are all important.

The principle impact of the operating nuclear power plant is in the area of local government finance, since the facility picks up large shares of a localities tax burden. (See Economic Unit - Tax structure.)

DISASTER READINESS

The state of readiness of a community in the event of a catastrophic occurrence is charged to the local Civil Defense Director. This officer is responsible, under Federal Law, for the preparation of plans, training of personnel, conduct of drills, and coordination of activities in the event of a disaster. The local Civil Defense Director is a county official and his activities are coordinated by a State Civil Defense Coordinator.

The format of a civil defense plan is specified by the Federal Civil Defense Guide and consists of a basic plan and a series of annexes that apply to a variety of eventualities: fire, flood, civil commotion, etc. Generalized categories contained in the basic plan (8) are:

I. Authority
II. Situation and Assumptions
III. Purpose
IV. Policy
V. Organization and Responsibilities
VI. Operations
VII. Direction and Control
VIII. Communications

In addition to these generalized categories, each local plan contains a list of specific individuals with their assigned function and with addresses and telephone numbers where they can be reached in an emergency. The plan must, therefore, be continually up-dated to account for personnel changes.

A summary of the content of each of the categories in the basic plan is given in Appendix S-3. A recommended addendum to the basic plan for handling a nuclear incident from whatever source is included. A conspicuous feature of this addition is the creation of a Radiological Defense Officer with broad authority and responsibilities in the matter of radiation detection and control.

COMMUNITY EDUCATION

A survey of a randomly selected group of Idaho Falls residents, together with a survey of high school students and a spot check of parts of Idaho and elsewhere, indicate that the general public is not adequately informed on nuclear energy.

Furthermore, a majority of the respondents agreed that their information was incomplete. A summary of the survey results is given in Appendix S-4. Only through a program of Community Education can this condition be corrected.

The CENT workshops are one means for providing people with information essential to intelligent decisions in nuclear energy matters. Unfortunately, practical considerations limit the number of people that can be reached by this method. It is important, therefore, that the first time this program is presented in a community, the workshop participants be selected from among the most influential citizens - mayors, councilmen, news media personnel, school teachers and administrators, and prominent businessmen. These people, because of their positions in the community, have excellent opportunities for passing on the information acquired in the course of this program.

The material contained in this curriculum was presented in a pilot workshop. Five two-to-three hour sessions were conducted on five successive Thursdays over a five-week period. This procedure is cumbersome, however, and does not reach a large audience. It is recommended, therefore, that instructors of such a five-session program use this material to produce one-hour programs for presentation to service clubs, school assemblies, civil defense meetings, and similar civil groups. Appendix S-5 lists alternative formats for presenting this material in different situations. Two five-session formats are shown - one as described above and a second for a one-week short-course type, such as might be used in a college or university summer course setting. The third format lists highlights from the student's text that might be used in a one-hour presentation.

COMMUNITY USE OF ENERGY

The effect of the intensive development of nuclear sources of energy on the economy is directly the result of the peculiar nature of the nuclear source. A recent study of the nature of alternative energy sources[1] classified them according to energy-densities and mobility. The uses of non-human sources of energy may be classified as follows: food production, transportation of materials and personnel, shelter (housing, heat, and light), and recreational. The application of nuclear energy to these uses, then, is conditioned by the fact that it is a high-density, immobile source.

The application of nuclear energy to all of the above uses is the result of the fact that it is used solely to produce electricity. It cannot grow anything; it does not directly induce chemical reactions; it cannot, except through the agency of electricity, transport anything from place to place; and it cannot build a house, again, except through the agency of electricity. Thus, the impact of nuclear energy must be considered in this context.

Alternative Sources

The large-scale use of nuclear energy for the generation of electricity releases other sources for alternative uses. It is wasteful to use oil and gas for generating electricity and space heating. These should be used for other applications for which electricity will not serve. For example, plastics, pesticides, synthetic fabrics, pharmaceuticals, recreational items, and building materials use oil, gas, and coal; these latter should not be burned for fuel.

It has been estimated[2] that 2.5% of all electricity generated in the United States from fossil fuels was used by agriculture. In 1970, only 0.3% of the total energy used by transportation was supplied by electricity.[3] The figures for these, plus residential, commercial, and industrial uses are shown in Table III-1. The same reference lists coal, oil, and gas as the alternatives to electricity as energy sources in these areas.

TABLE III-1

Applications of Electricity[3]

Agriculture	2.5% of U.S. Electricity (1975)
Transportation	0.3% of Transportation Energy (1970)
Residential	28.2% of Residential Energy Use (1970)
Commercial	29.1% of Commercial Energy Use (1970)
Industrial	22.3% of Industrial Energy Use (1974)

Agriculture Uses

It has been estimated[4] that about 16.5% of the total energy consumption in the United States is used in food production. This 16.5% was attributed to production, manufacturing, distribution, and processing; production includes labor, machinery, fertilizers, pesticides, and fuel. Of the total energy input, direct electricity usage constitutes about 5% of the total. Certainly, there is a hidden electricity usage in the production of fertilizers and pesticides among other things. As far as agriculture is concerned, however, it makes little difference how the electricity is generated, unless, of course, the means for that generation is depleted. This is the importance of nuclear power; the development of nuclear power can assure the continued supply so necessary to an assured food supply.

Transportation Uses

The alternatives to electricity for transportation are the fossil fuels. Nuclear energy is of little value because of its immobility, for the foreseeable future, that is. A technology is known, but not commercially developed, whereby hydrogen is produced by the electrolysis of water. Hydrogen is then stored in metal hydrides and withdrawn as needed in an internal combustion engine (like in automobiles) for mobile uses.

Other Uses

Similar comments can be made for the other uses of electricity: residential, commercial, and industrial. Although direct use ranges between 25% and 30%, there are hidden uses in some of the components of these items.

Conclusions

The above analysis emphasizes the fact that the generation of electricity by whatever means is crucial to the entire economy; so crucial, in fact, that electricity has come to be regarded by many as an energy source, whereas in fact it is only a convenient means for moving energy from one place to another - from the place the energy is found to the place where it is to be used. Cheaper ways exist for transporting energy,[5] but they lack the convenience of electricity. It is possible that the greater convenience may be worth the difference in cost, but that is a subjective judgement not readily subject to exact analysis.

Thus, the use of nuclear energy to produce electricity affects primarily the other sources, namely the fossil fuels, oil, gas, and coal. The Energy Tax Act of 1978[6] encourages the replacement of oil and gas by coal in electricity generating plants. These shifts in the kind of usage of these sources and/or their replacement by nuclear energy can have profound effects on the nature and areal distribution of the job market. For example, the extreme case of the entire replacement of the gasoline engine by a hydrogen engine as suggested above, would completely disrupt the whole oil refining and marketing system. Such an eventuality is not very likely at present. but it suggests a possibility that might be considered. The social disruption that might result is difficult to imagine.

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3) Energy Alternatives: A Comparative Analysis, p. 13-33, The Sci. and Public Policy Prog., University of Oklahoma, Norman, Oklahoma. (May, 1975)

4) Annual Review of Energy, p. 171.

5) See reference 2 in Technological Unit.

6) Landsberg, H. H., (Ed.) Energy: The Next Twenty Years, p. 302. The Ford Ford Foundation. (1979)

7) "Boom Towns May Hinder Energy Resource Development," John Gilmore, Science, February 13, 1976.

8) "Bonneville County Emergency Operating Plan," Civil Defense.

APPENDIX S-1

Citizen Education on Nuclear Technology (CENT)

This questionnaire is not a test. Its purpose is to evaluate the opinion climate regardless of how those opinions may have been formed. The goal is not only to find out what those opinions are, but also to find out the source of the information that formed the basis for those opinions. The subject matter of this course then will provide factual information derived from authoritative sources.

Age Bracket
______ under 20
______ 20 - 40
______ 40 - 60
______ over 60

Educational Level
______ Grade School
______ High School
______ College or University
______ Post Graduate

1. Do you believe the construction of nuclear power plants should be:

   a. abandoned
   b. continued at the present rate
   c. continued in preference to fossil-fueled plants
   d. continued only if fossil-fueled plants or other alternative energy sources prove inadequate to the country's needs

2. Do you believe nuclear power plants to be:

   a. unsafe in every respect
   b. as safe as most industries
   c. completely safe in every respect
   d. a dangerous device that can be operated safely by proper management and training of personnel

3. Do you believe that further research to improve nuclear power safety and efficiency should be:

   a. abandoned
   b. continued but at a reduced rate
   c. continued at the present rate
   d. continued at a faster rate

4. Under what conditions would you accept employment in a nuclear power plant:

   a. under no conditions whatsoever
   b. only if the salary and fringe benefits were several times greater than elsewhere
   c. only if no other work were available
   d. if the salary and benefits were equal and it were convenient as compared with other sources of employment

71

5. Do you believe the continued construction and research on nuclear power plants to be:

   a. disastrous to the environment, the economy, and the overall welfare of the public
   b. no threat to the environment and necessary to the economy and welfare of the public
   c. detrimental to the environment but necessary to the national economy
   d. beneficial to the national welfare far in excess of the risks involved

6. Do you believe the question of nuclear waste disposal to be:

   a. a completely unsolvable problem
   b. solved technically, but used as a political football
   c. not yet solved, but technically solvable
   d. solvable, but solutions hampered by political considerations

7. If a nuclear power plant were being built or planned for your community, would you:

   a. move to another area immediately
   b. like to move, but economically restrained
   c. move if convenient to do so
   d. never give it a second thought

8. Which energy alternatives do you believe should be developed most intensively:

   a. fossil fuels (coal, oil, gas)
   b. solar, wind and related sources
   c. hydroelectric
   d. nuclear
   e. all of the above
   f. none of the above

9. As regards nuclear power plants currently in operation, do you believe:

   a. they should be shut down and all facilities dismantled and all salvagable equipment disposed of
   b. they should all be shut down temporarily until safer operating procedures are developed
   c. they should be allowed to continue operation, but better safeguards should be instituted and operator competence upgraded
   d. they should be allowed to continue operating as before

10. What source of nuclear energy information do you consider to be the most accurate:

   a. news media (newspapers, magazines, radio, TV)
   b. governmental reports
   c. consumer organizations - Nader, Sierra Club, etc.
   d. industry spokesman
   e. none of the above
   f. all of the above

11. With respect to nuclear power, which situation do you believe is the current one:

   a. the information exists, but is not available to the public in understandable form
   b. the information currently available to the public is all it needs to know
   c. the information is available, but some is being/has been purposely withheld
   d. the general public doesn't much care

12. With respect to the current energy situation, do you believe that:

   a. the energy situation is critical
   b. the energy situation is serious, but not critical
   c. the energy situation is somewhat serious
   d. the energy situation is not serious

13. What is (are) your source (s) of information on nuclear energy: (mark as apply)

   a. newspapers and/or news magazines
   b. radio and TV
   c. personal involvement
   d. technical journals
   e. all of the above
   f. none of the above

14. Have you read the report of the President's Commission on the Three Mile Island incident:

   Yes__________

   No__________

15. Have you read Admiral H. G. Rickover's testimony on the Navy's Nuclear Propulsion Program before a congressional committee?

   Yes__________

   No__________

APPENDIX S-2

The Risk Game

Purpose:

The purpose of the Risk Game is to measure the importance people attach to the element of risk when making decisions relating to how they conduct their lives.

Discussion:

The activities people choose to engage in are many and varied, and the choices they choose to make depend on many factors: personal preference for which there is no accounting, peer pressure, financial gain, recreational goals, improvement of health, and perhaps others considered to be of importance to the individual. Whatever choices people make, there is the ever-present element of risk. Riding a motorcycle without a helmet is more risky than riding with one; coal mining is a more risky occupation than basketball coaching, yet there are people who will choose each. Thus, the question arises, "What importance do people attach to the element of risk when they choose the activities they engage in?"

Procedure:

The participant is asked to choose a stated number of activities (seven is a suitable number) from a list for which the activity only is known. Next, he is asked to choose the same number from a list for which the risk only is known. Lastly, he chooses the same number from a list of activities with the associated risk shown. The average risk is then calculated for the choices made from each list, and the averages are compared.

Analysis:

A risk is defined as the probability of occurrence of an event multiplied by the consequences, should that event actually occur. In the Risk Game, the probability of an accidental death is given for each activity. Thus, the consequence is death and the probability is stated in the lists as one death per year per number of persons engaged in that activity. Therefore, the larger the number of persons involved, the safer the activity.

In making a choice from the list of activities, it is expected that a person will make a selection based partially on his preferences and partially on his knowledge of the risk attached to those activities. The choices will reflect on how personal preferences balance against the subjective perception of the associated risk.

The list of risks is arranged in a random order compared to the activities list. Without a knowledge of the nature of the activity, it is expected that the rational individual will choose the low-risk items (large numbers in the list).

In these lists, the activities and associated risks were taken from statistical data given in the 1978 report of the National Safety Council and from reports of the Atomic Industrial Forum. These risks may or may not coincide with the individual's original perception of them.

It is expected that the choices made from the activities-risk list will more accurately reflect the balance the individual makes between risk and preference. The calculated average risk from this list, therefore, might be larger or smaller than that from the first list.

The differences in the magnitudes of the averages from the three lists will indicate the importance the individual attaches to risk. If the averages are reasonably close, then one might conclude that the individual has a good knowledge of associated risks and has adjusted his preferences to low risk activities. If the differences are large, then one might conclude that preferences override risk in the individual's choice of activities.

APPENDIX S-3

Summary of Content of Basic Civil Defense Plan.

I. Authority

County Civil Defense organizations operate under the authority of the Federal Civil Defense Act of 1950, as amended, 50 USC App. Sec. 2251-2297. Additional authority pertains to the requirements of the various state codes, the county actions, and city-county agreements.

II. Situation and Assumptions

In the basic plan, the assumptions deal with the possible sources of an emergency. The participants of the workshop should determine that a bona fide nuclear incident is included in the basic plan for their community.

The situation describes in a general way, the population magnitude and distribution, facilities available, and actions that can be taken in an emergency. Reference is made to legally constituted authorities and existing defense readiness plans at the state and local levels.

III. Purpose

A standard phraseology is "...to provide for the maximum protection of life and property and to prevent, minimize, repair, and recover from injury and damage caused by ...a disaster."

IV. Policy

Consists of a statement of the responsibilities of the city and county elected officers of government. Supplementary use of trained auxiliaries is authorized.

V. Organization and Responsibilities

Whereas the responsibilities described under IV-Policy above were general in nature, this section spells out specific duties. The following officials are mentioned specifically:

- County Commissioners
- Mayor
- Civil Defense Council
- Civil Defense Coordinator

The duties of the following services are also spelled out:

- Fire Service
- Law Enforcement Service
- Health Service
- Welfare Service
- Shelter Service
- Public Information Service
- Disaster Analysis
- Public Works Service

An Operations Group is established, an Emergency Operating Center is set up, and provisions for Military Support are made.

VI. Operations

This section outlines in general the procedures to be followed in the event of natural disasters and war-caused disasters. Details of actions to be taken in specific cases are spelled out in the separate annexes. All of this is the province of the Civil Defense Director and the state, county, and city-elected officials. Workshop participants should satisy themselves that these matters have been satisfactorily accomplished. In other words, a functioning Civil Defense organization should exist. The procedure to be followed in the event of a nuclear incident is covered in an annex prepared along the lines discussed above.

VII. Direction and Control

All steps taken to direct the activities of disaster control teams originate at the Emergency Operating Center. This section sets up such an EOC, describes its capabilities, staffing, and operating procedure.

This section also prescribes the types, content, procedures, and agencies making reports.

VIII. Communications

This section describes and defines all normal and emergency lines of communication among the normal agencies of government and between emergency field communication units and the EOC.

Sections VII and VIII would apply, regardless of the nature of the emergency.

Suggested Disaster Plan for Use During A Nuclear Incident

I. Authority

(See Basic Plan)

II. Situation

Capabilities

This paragraph should list and define the following items pertaining to the local situation. Workshop participants assemble this material with the cooperation of the local Civil Defense Office.

1. Radiological survey teams available;
2. Location and capacity of fall-out shelters;
3. Medical facilities available;
4. Evacuation routes available;
5. Emergency housing available;
6. Reserve police for special duties.

Limiting factors should list deficiencies in the items listed above.

III. Purpose

(See basic plan)

IV. Policy

A. The conduct of preventive and protective actions shall be the responsibility of specially trained personnel, fully knowledgeable of accepted methods of dealing with radiological problems.

B. Recruitment, training, assignment, and supervision of radiological defense teams shall be the responsibility of a Radiological Defense Officer reporting to the Civil Defense Director.

V. Organization and Responsibilities

A. Organization

1. The Radiological Defense Officer shall organize Radiological Defense Teams. Existing units of the Sheriff's office, and city and state police organizations shall be integrated into such teams.

B. Responsibilities

1. The Radiological Defense Officer shall have the sole responsibility of deciding, after a consultation with responsible nuclear power plant officials and law enforcement officers, whether to evacuate residents, to utilize fallout shelters, or what protective action to employ in the best interests of residents in the vicinity of the affected nuclear power plant.

2. Law enforcement officials shall be responsible for the usual matters falling within their jurisdiction under normal conditions, as long as they do not conflict with the radiological situation.

3. Local law enforcement officials, the Radiological Defense Officer, the Civil Defense Director, and the local city and county officials shall prepare an evacuation plan and a plan for establishing, stocking, and administering fallout shelters.

VI. Operations

A. Disaster Relief

Disaster relief in the event of a nuclear incident at a nuclear power plant shall be conducted jointly by the Civil Defense Director and the Radiological Defense Officer, according to the established plans.

B. Pre-disaster Activities

Pre-disaster activities shall consist of personnel training sessions, assignment of personnel to specific tasks, and test and exercises. Additional activities shall consist of detailing plans in the following areas;

1. Public warning
2. Movement to shelters
3. In-shelter administration
4. Evacuation plans
5. Recovery
6. Public information processes before and in the event of an incident.

VII. Administration and Logistics

Plans falling under this heading are common to other subjects described in other annexes. Reference should be made to them.

APPENDIX S-4

NEEDS ASSESSMENT

The needs assessment survey was conducted with the assistance and cooperation of the Bonneville County District 91 school administration and the Boy Scouts of America Teton Peaks Council. Students listed in the Advisory Committees above and a Scout candidate for the Eagle rank did most of the work of obtaining respondents to the questionnaires. The various city precincts were assigned and the students were instructed in the procedures. The canvass of the high school students was conducted by the teachers on the Environmental Education Advisory Group.

Results and Analysis of Survey

Results:

	Idaho Falls Residents	Civil Defense Directors	High School Students	U. S. Spot Check
Number of Respondents	172	15	133	28
Percentage Responses (attitudes toward Nuclear Energy)				
(1) Public is informed:	21%	7%	24%	4%
Public not informed:	79%	93%	74%	96%
(2) Nuclear Power safe:	75%	80%	84%	64%
Nuclear Power not safe:	25%	20%	16%	36%
(3) Would move:	21%	27%	14%	61%
Would not move:	79%	73%	82%	39%
(4) Benefits Outweigh Risks:	68%	86%	80%	46%
Benefits Do Not Outweigh:	28%	14%	20%	54%
(5) Waste Problem Political:	60%	53%	59%	46%
Waste Problem Technical:	33%	40%	35%	54%
(6) Prefer Alternative Sources:	48%	47%	36%	64%
Prefer Nuclear:	52%	33%	51%	29%

The indicated responses are keyed to the question numbers in the questionnaire. The sense of the questions is given in abbreviated form to avoid the necessity of writing out the questions verbatim.

Percentage Responses (Sources of Information)

	Idaho Falls Residents	Civil Defense Directors	High School Students	U.S. Spot Check
(7) Accuracy of Sources -				
Most Accurate:				
(a) News Media	28%	7%	13%	21%
(b) Govt'l. Reports	17%	20%	19%	7%
(c) Consumer Organizations	15%	20%	12%	43%
(d) Industry Spokesmen	22%	27%	29%	21%
(e) None of Above	24%	40%	29%	14%

80

	Idaho Falls Residents	Civil Defense Directors	High School Students	U. S. Spot Check
(8) Preferred Forms of Sources -				
(a) Random Items in Media	24%	27%	31%	39%
(b) Front Page Items	12%	0	5%	0
(c) Serial Articles	28%	40%	35%	61%
(d) Workshops	44%	60%	45%	57%
(9) Publicity on Demonstrations -				
(a) Full, complete accts.	31%	20%	25%	54%
(b) Ignore them	9%	33%	6%	7%
(c) Newsworthy Items	36%	40%	27%	18%
(d) Balanced Accts.	27%	13%	46%	25%
(10) Sources Used by Respondents -				
(a) Papers & Magazines	71%	67%	84%	76%
(b) Radio and TV	73%	67%	75%	82%
(c) Personal Involvement	40%	73%	41%	76%
(d) Technical Journals	20%	40%	18%	64%

One Civil Defense Director returned fifty-seven completed questionnaires from his area. Nothing is known of his manner of selecting respondents; hence, the representative nature of the results is open to question. The results are presented, however, for comparison purposes.

CANYON COUNTY, IDAHO SURVEY:

Number of Respondents - 57

(1)	Public is informed:	7%
	Public is not informed:	93%
(2)	Nuclear Power is Safe:	70%
	Nuclear Power is not Safe:	25%
(3)	Would move:	41%
	Would not move:	56%
(4)	Benefits Outweigh Risk:	75%
	Benefits do not Outweigh:	18%
(5)	Waste Problem Political:	44%
	Waste Problem Technical:	46%
(6)	Prefer Alternatives:	61%
	Prefer Nuclear:	33%
(7)	Most Accurate Sources:	
	(a) News Media	4%
	(b) Gov't. reports	12%
	(c) Consumer organizations	25%
	(d) Industry spokesmen	30%
	(e) None of these	33%

(8) Preferred Forms of Sources -

(a) Random Items in Media	16%
(b) Front Page Items	2%
(c) Serial Articles	51%
(d) Workshops	49%

(9) Publicity on Demonstrations -

(a) Full, complete account	16%
(b) Ignore Them	19%
(c) Newsworthy Items	47%
(d) Balanced Accounts	16%

(10) Sources used by Respondents -

(a) Papers and Magazines	75%
(b) Radio and TV	79%
(c) Personal Involvement	70%
(d) Technical Journals	25%

ANALYSIS

The results indicate that an overwhelming percentage of respondents believe the public is not sufficiently informed on nuclear energy matters. Even so, about the same percentage believe nuclear power to be at least as safe as other industries. The responses to Questions 3 and 4 reinforce the conclusion indicated by the response to Question 2 in the three local (Idaho Falls residents, C. D. Directors, and Students) categories. The small number of respondents in the "Spot Check" gave answers to Questions 3 and 4 inconsistent with their answer to Question 2. This result would seem to indicate that the country as a whole is not well-informed, or that the Spot Check respondents did not understand the questions. Because of the proximity of the Idaho National Engineering Laboratory, the local residents might be expected to be better informed than the country as a whole.

The response to Question 5 is not as clear cut as the responses to the previous questions, which probably reflects the lack of factual information on the part of most respondents. The response to Question 6, on the whole does not show any clear preference for any one alternative energy source.

Questions 7 through 10 delineate the attitudes toward, and preferences for the various information sources.

A public opinion survey about the Black Fox Nuclear Plant was conducted for the Public Service Company of Oklahoma by Central Survey, Inc., of Shenandoah, Iowa, during the period February 10-17, 1979. The results of that survey of residents "fairly close to the site of the Black Fox Station" were 41% in favor, 21% opposed, 29% indifferent, and 9% no opinion. Some of the recommendations made by Central Survey, Inc., are:

(a) "..........the company should consider increasing its efforts to give residents of this area factual information about nuclear power, and specifically about the Black Fox."

(b) "...,there seems to be a serious lack of information on some subjects."

(c) "....only the most sophisticated (and most interested) residents of the area thoroughly read and understand the conflicting arguments."

One could conclude, therefore, from the results of this survey and that made by Central Survey, Inc., that, a) there is a need to motivate community residents to become interested, and b) that there is need to provide readily understood factual information to citizens faced with the necessity of making decisions relative to nuclear power.

APPENDIX S-5

Workshop Schedules

Five-Session Symposium

The five-session symposium may be conducted in two different formats. The first is designed for the general public. It consists of five two-to-three hour sessions held in the evening on some selected day of the week for five successive weeks. The second schedule is a one-week symposium suitable for a multi-disciplinary college or university summer session. Both formats use the student's text and the teacher's guide.

Five-Week Format

First Week

1. Registration and distribution of student texts.
2. Complete questionnaire in Sociological Unit.
3. Instructor explains plan of course and conducts class discussion on questions in questionnaire.
4. Assignments:
    1. Read Technology Unit and answer as many questions as possible.
    2. Collect energy-oriented cartoons from newspapers and magazines.

Second Week

1. Class discussions
    a. Explain and complete technology questions.
    b. Class discussion on substance of cartoon contents.
2. Assignments: Read sociological and environmental units. Look for examples of energy-slanted advertising by industry.

Third Week

1. Clear up any as-yet unanswered questions in the Technology Unit.
2. Discuss questions to be found in student's text on Sociological and Environmental Units.
3. Assignments: Read Economic and Political Units.

Fourth Week

1. Discussion led by instructor, based on questions to be found in student's text, and in teacher's guide, on Political and Economic Units.
2. Conduct Risk Game - score and explain intent of game and significance of results.
3. Assignment: Review course material and formulate any questions on course work. Read Decision Module.

Fifth Week

1. Final Review
    a. Answer questions from workshop participants.
    b. Discuss Decision Module.
2. Analyze and discuss content of cartoons.
3. Complete evaluation questionnaire.

One-Week Format

First Day

Morning 9:00 - 12:00

1. Registration and distribution of student texts.
2. Complete questionnaire in Sociological Unit.
3. Instructor explains plan of course and conducts class discussion on questions in questionnaire.
4. Assignments: (a) Read Technology Unit and answer as many questions as possible.
   (b) Library Work: Collect energy-oriented cartoons from magazines and newspapers.

Afternoon: Work on assignments.

Second Day

Morning: 9:00 - 12:00

1. Class discussions.
   (a) Review and explain technology questions.
   (b) Discuss cartoons.
2. Assignments: (a) Read Sociological and Environmental Units.
   (b) Library Work: Look for energy-related advertising by industry.
   (c) Complete technology questions.

Afternoon: Work on assignments.

Third Day

Morning: 9:00 - 12:00

1. Class discussions
   (a) Clear up any unanswered questions on Technology Unit.
   (b) Conduct Risk Game.
   (c) Complete personal inventory in Table II, Environmental Unit.
   (d) Pose questions from Teacher's Guide and discuss them.
2. Assignment: (a) Appoint delegation to call on Civil Defense Office to obtain information on Civil Defense plans in the event of a nuclear incident.
   (b) Read Economic and Political Units.

Afternoon: Work on assignments.
Participants not calling on Civil Defense, assist instructor in analyzing Risk Game results.

Fourth Day

Morning 9:00 - 12:00

1. Class discussions

   (a) Discuss questions found in student's text and in teacher's guide on Political and Economic Units.
   (b) Receive report on delegation calling on Civil Defense.
   (c) Receive results of Risk Game.

2. Assignment: Review course material and formulate any questions on course work. Read Decision Module.

Afternoon: Work on assignment.

Fifth Day

Morning 9:00 - 12:00

1. Final review

   (a) Answer questions from participants.
   (b) Discuss Decision Module.
   (c) Discuss content of cartoons.

2. Complete evaluation questionnaire.

3. Organize groups for dissemination of nuclear technology information.

4. Collect participants' comments.

One-Hour Format

This one-hour prepared text on nuclear energy is based on material contained in the student's text, titled Citizen Education on Nuclear Technology (CENT).

As one of the participants in the pilot workshop commented, "If one is selling shoe polish, one doesn't tell the customer what is in it; one tells him how well it polishes shoes." He might have added that one also tells the customer how much better job the polish does than that of a competitor. This text, therefore, avoids technical details and tells the listener how well nuclear energy does the job and how much better it is than alternative sources.

The areas covered in this prepared text are nuclear safety, cleanliness, and cost. A time allowance is also made for questions.

The Case for Nuclear Power

(a prepared text)

The result of a survey of local residents, Idaho Civil Defense directors, and a few randomly selected respondents elsewhere, showed that the public did not consider themselves to be adequately informed on energy matters in general or on nuclear energy. The consensus was that available sources were not providing the necessary information. That is unfortunate because the data do exist on which to base intelligent decisions.

The subject is so vast and so complex that it would be foolish to think that this short discussion might answer all the possible questions concerning the energy issue. The best that can be done is to point out the broad areas of concern and to tell where the desired information can be found.

At the very start, it is strongly emphasized that a complete understanding of all the technical aspects of the issue is not needed for one to arrive at rational conclusions on the energy issue. A certain amount of mental effort is, however, required.

The energy issue in general and the nuclear energy issue in particular, can be broken down into the following segments: the identity and magnitude of the most likely alternatives, estimates of future demand, operational safety, including environmental and ecological impact, socio-economic implications, and questions of national policy.

Viable alternatives for the foreseeable future are only three in number: fossil fuels, solar, and nuclear. Of these, only fossil fuels and nuclear have reached the level of technological development necessary to meet a major part of the estimated demand. Solar, which includes wind and hydro-power, has not yet reached the point where widespread commercial applications are likely in the near future. Of course, hydro-power is a major source in a few favored areas, but very much additional application is not expected, simply because all suitable potential has already been exploited.

Operational safety, including environmental and ecological impact, is the battleground on which the pro- and anti-nuclear forces are locked in mortal combat. Socio-economic and policy questions are minor skirmishes on the periphery of the malestrom.

Geothermal energy, ocean tides, ocean waves and thermal gradients, and biomass are minor alternatives on the sidelines, just waiting to join the fray.

Factual information, as well as expert (and not so expert) opinion, is available to anyone with the interest and inclination to dig it out. In 1975, the then U. S. Energy Research and Development Administration requested the U. S. National Academies of Science and Engineering to make a "comprehensive analysis of the nation's energy future, with special consideration of the role of nuclear power." The study was conducted by the "parent Committee on Nuclear and Alternative Energy Systems (CONAES), four assessment panels, and some two dozen subcommittees, involving, in total, over 250 persons." Some of the findings of this study are currently in press, and hence, not immediately available. However, an in-depth review of the work of that committee by two of the members of CONAES may be found in Annual Review of Energy, Vol. 4, (1979).(1) Additional sources of authoritative information are the Report of the President's Commission on the Three Mile Island Accident, and the testimony of Admiral Hyman G. Rickover before the Congressional Committee on Energy in May, 1979. If the local library does not have these publications, one should insist that they be acquired as essential to a public understanding of the issues. Additional suggested reading is listed in the bibliography.

An informed public is crucial to the resolution of the current energy crisis. In this context, a quote from the above referenced article is pertinent.

"The CONAES study, like others before it, concluded that there are divergent pathways this nation can follow toward its energy future. Which path is pursued will ultimately be a matter of social choice. But, whichever road is followed, deliberate and timely actions by government will be required, and many will touch sensitive nerves in this pluralistic society. Building the political consensus necessary to an effective policy will, therefore, be difficult. An important ingredient of this effort is to replace myths with facts and to reduce uncertainties as much as possible. With these objectives, CONAES attempted to assemble a solid data base which would assist both the decision maker and the public to identify and evaluate the consequences of alternatives and often conflicting energy goals, options, costs, benefits, tradeoffs, and mixed strategies."

The public, therefore, is strongly encouraged to consult the reports on this study as they are issued. Only thus can a rational opinion be formed, and not by relying on the words of the excessively vocal self-appointed guardians of the public good.

Man's rise from savagery to civility has been marked by one dominant theme, namely, the search for sources of energy to do his work for him. The all-consuming struggle for survival left primitive mankind little time for anything else. Crucial discoveries such as fire and the domestication of animals provided the entering wedge that freed a few individuals for pursuits other than grubbing out a living from the recalcitrant soil. The discovery of the means for controlling fire opened the way for the burning of wood and coal for heat, and of animal and vegetable oils for light. Domestic animals assisted in the soil-grubbing process and provided man with increased mobility. Coal was introduced into Western Europe in the late 13th century by Marco Polo, and petroleum was discovered in the United States in the middle of the 19th century. Natural gas, a petroleum by-product, came into widespread use in the early 20th century. In 1939, Hahn and Strassman discovered nuclear fission and the nuclear age began. Thus, nuclear energy marks the latest step in man's search for ever better sources of energy to do his work for him.

All progress, however, has its good and bad aspects. The invention of the bow and arrow immeasurably improved man's ability to feed himself, but the arrow that killed his meat also killed man. Fire soon proved to be a dangerous slave, if out of control, and nuclear energy is no different. Thus, nuclear safety is of prime concern to the nuclear reactor engineer.

The recent incident at Three Mile Island alerted the public to the possible hazards associated with the use of nuclear energy. Nuclear safety, however, is not a new problem. From their inception, nuclear reactors have been recognized as dangerous devices and both government and industry have been engaged in intensive research into the design of safely operating reactors. Safety, however, involves more than machine design. The human factor cannot be ignored. This fact is vividly apparent on consideration of the findings of the President's Commission on Three Mile Island as compared with Admiral H. G. Rickover's testimony before a congressional committee. That Commission stated in its report, "We are convinced that if the only problems were equipment problems, this Presidential Commission would never have been created." And again, "...the fundamental problems are people-related problems, and not equipment problems."

In contrast to industry-operated nuclear power plants, it is refreshing to look at the record of the Navy's Nuclear Propulsion Program's safety record. In his testimony, Admiral Rickover stated, "In the 26 years since the Nautilus land prototype first operated, which was in 1953, there has never been an accident involving a naval reactor, nor has there been any release of radioactivity which has had a significant effect on the environment." This record becomes all the more impressive in the light of the following facts:

127 nuclear powered ships in operation
508 nuclear cores procured
166 refuelings
40 million miles steamed by nuclear powered navy ships
1800 reactor-years of operation

How was it done? Admiral Rickover gave the answer. "You have to depend on people. If you have to depend on people, then they must know what they are doing. That means training not only once, but constantly. That is why people are required to go to church every week. The ordinary human being does not remember anything longer than a week."

One is forced to conclude that if the navy can operate nuclear reactors safely, then industry ought to be able to do likewise.

To place the whole question in the proper perspective, it is instructive to consider accident rates as compiled by the National Safety Council. Table S-5-1 lists the risk associated with a variety of common activities. The risk is stated as one accidental death per year per size of population.

TABLE S-5-1

Risk of Accidental Death

Risk of Death in the Home	1 per year per 7700 population
Risk of Death in an Automobile	1 per year per 4000 population
Risk of Death in an Aeroplane	1 per year per 100,000 population
Risk of Death in Coal Mining	1 per year per 196 population
Risk of Death by Lightning	1 per year per 2,000,000 "
Risk of Death in a Nuclear Power Plant	1 per year per 5,000,000,000 "

But there are other hazards associated with nuclear energy. The most feared are the effects of exposure to radiation. The Advisory Commission on the Biological Effects of Radiation, National Research Council, has issued the results of a study on the life-shortening effects of various common activities. Table S-5-2 is taken from that study.

TABLE S-5-2

Life-Shortening Effects of Various Factors in Human Experience

Factors Tending to Decrease Average Lifetime	Decrease in Average Lifetime
Overweight by 25%	3.6 years
Smoking 1 pack cigarets per day	7.0 years
Smoking 2 packs cigarets per day	10.0 years
City versus country living	5.0 years
Radiation from nuclear power plants (1970)	Less than one minute
Estimate for year 2000 with 100-fold increase in nuclear power production	Less than 30 minutes

Opponents of nuclear energy have demanded that nuclear reactors be designed with zero risks. Admiral Rickover has pointed out that machines "...cannot be made perfect. The human body is God's finest creation and yet we get sick. If we cannot have perfect human beings, then why should we expect, philosophically, that machines designed by human beings will be more perfect than their creators? That is what many unthinking people demand, even though the Lord Himself did not reach this height."

We come now to the subject of cleanliness. Cleanliness deals with the production of waste products that must be disposed of in some manner. Again, we cite comparative studies in Table S-5-3.

TABLE S-5-3

Waste Products

Coal - 12 tons of ash per 100 tons burned
242 tons CO_2 per 100 tons burned
Radiation exposure of general public - 0.3 millirem/year

Nuclear Energy - 8 pounds fission products per 100 tons of ore mined
Radiation exposure to general public - .005 millirem per year

Other emissions and products are oxides of sulphur and nitrogen for coal and plutonium for nuclear reactors. The former can be partially removed by scrubbers, which greatly increases the cost of electricity. The most obvious means for disposing of the plutonium is to put it in a reactor to make electricity in the same way uranium is used.

There remains the question of how to dispose of those 8 pounds of fission products. It has been calculated that one cubic meter (a little more than a cubic yard) of those same fission products produces enough gamma heat for the equivalent of four average homes. Hence, the fission products become an alternative energy source.

Cost figures also favor nuclear power. Table S-5-4 shows relative costs from studies of the Atomic Industrial Forum and the Westinghouse Corporation.

TABLE S-5-4

Comparative Energy Costs

Source	Electrical Costs 1976	1978
Coal	1.8 cents/kWhr.	2.3 cents/kWhr.
Oil	3.5 cents/kWhr.	4.0 cents/kWhr.
Nuclear	1.5 cents/kWhr.	1.5 cents/kWhr.

Utilities using both nuclear and fossil fuel facilities have estimated that dollar savings to their customers have occurred because of the availability of nuclear power. Table S-5-5 shows those cost savings.

TABLE S-5-5

1977 Cost Savings to Typical Residential Customers

Wisconsin	$ 8 per year
Philadelphia area	$ 16 per year
New England	$180 per year
Baltimore	$ 81 per year

These are all short-term considerations; in the long term, other factors need to be considered. The anti's appear to think that it is only necessary to utter the words 'solar' and 'coal' to clinch the argument against nuclear energy. Consider, however, the facts.

An article in the Transactions of the American Geophysical Union for July, 1972, discusses the Large Scale Concentration and Conversion of Solar Energy. The aluminum to build the mirrors would consume the entire United States' production of alumiunum for 38 years at the 1969 production rate; and the life of the system was estimated to be 30 years. The system would cover an area of 30,880 square miles. In addition, steel would be needed for mirror supports; control circuits would direct the sun's light on the conversion unit; a conversion unit would generate electricity; and a storage system would store the energy on off periods when it would not be needed. Because of the diffuse nature of solar energy, it is only suitable for small scale de-centralized uses.

The hazards associated with the widespread use of coal are only just now beginning to be realized. The consequences of acid rain have received some newspaper exposure. Acid rain results from the oxides of sulphur and nitrogen produced by the burning of coal. Scrubbers can remove most, but not all, of these oxides and their use increases the cost of the electricity to the point where it is no longer competitive with nuclear energy. The real hazard, however, is catastrophic and probably fully realized by only a handful of knowledgeable scientists. The hazard referred to is the increased greenhouse effect produced by an increase in the carbon dioxide content in the atmosphere from burning coal. It was stated above that 100 tons of coal produced 12 tons of ash when burned. That means that about 66 tons of carbon are burned to produce carbon dioxide (CO_2), since about 3/4 of the difference between 12 and 100 consists of carbon. The other constituents are hydrogen, nitrogen, oxygen, and sulphur in varying percentages. Hence, the burning of 100 tons of coal produces 242 tons of CO_2.

It has been estimated in a report of research in a recent issue of the Journal of Geophysical Research of the American Geophysical Union that the consequence of a 100% dependence on coal would result in an increase in the worldwide average temperature at the surface of the earth of nine degrees centigrade, by the year 2100. It has been further estimated that if the surface temperature of the world's oceans were increased by only 5 degrees, the resulting thermal expansion of the water alone would put every coastal city in the world under water. Furthermore, this worldwide increase in temperature would melt both polar ice caps and the Greenland ice cap; and only the tips of the New York skyscrapers would be showing.

The anti-nuclear lobby has accused government and industry spokesmen of bias when all the while, they vociferously express their own bias. But bias is not all bad. Only those who have no opinion at all are completely free of bias. Bias may be the result of expert knowledge, on the one hand, or complete ignorance of the subject on the other. What is required is balance, rather than the elimination of bias. To attain such balance, it is necessary to consider advantages and disadvantages of alternatives in both the short term and the long term.

"With respect to the environment and energy, uncertainties about the future impacts of current choices suggest that what are acceptable or even good choices for the immediate future may prove less satisfactory for the distant future. Obviously, this could be true of social and economic choices as well, but the scale of effects as well as the reversibility and the time required to reverse some environmental impacts, may be quite long." (Energy: The Next Twenty Years, H. H. Landsberg. Ballinger Publishing Company, Cambridge, Massachusetts (1979) pp. 369-370.)

It might be concluded, therefore, that the energy crisis in general, and the nuclear energy issue in particular, cannot be solved by the emotional outbursts and anguished antics of misguided activists. Sober reflection and rational analysis will be necessary for the resolution of these issues.

APPENDIX S-6

Adult workshops and secondary school curricula are two avenues for the dissemination of the material in the Student's Text. Newspaper articles constitute a third public education process. Two formats designed for the latter application are given in this appendix.

Single Article Format

For a single article, the One-Hour Format of Appendix V can be used.

Mini-Series Format

The following series of six articles is based on the material in the Student's Text. It was published in the Idaho Falls Post-Register daily newspaper for July 17, 1980, through July 23, 1980.

Part 1 of a Series on Nuclear Energy

One dominant theme has run through all of man's history during his rise from savagery to civility, and that is his search for non-human sources of energy to do his work for him. Prehistoric hominids warmed themselves in the sun, but the rest of their time was spent eking out a living from an unfriendly nature. The discovery of the use of fire and the domestication of animals partially freed man from the all-consuming task of grubbing out a living from the recalcitrant soil. The control of fire opened the way for the burning of wood for heat, and of animal and vegetable oils for light. Domestic animals assisted in the soil-grubbing process and provided man with increased mobility. Coal was introduced into Europe by Marco Polo during the late 13th century. Petroleum was discovered in the United States during the middle 19th century. In 1939, Hahn and Strassmann discovered nuclear fission and the nuclear age began. Thus, nuclear energy marks the latest step in man's search for ever better sources of energy to do his work for him.

All progress, however, has its good and bad aspects. The invention of the bow and arrow immeasureably improved man's ability to feed himself, but the arrow that killed his meat also killed men. Fire soon proved to be a dangerous slave, if out of control, and nuclear energy is no different.

Throughout man's long history of his exploitation of non-human energy sources, there has been this constant battle between the good and bad aspects of progress. Columbus had some difficulty in recruiting seamen for his westward voyage because they were afraid they might fall off the edge of the earth. Franklin's lightning rod was opposed on the grounds that it was sacrilegious. The use of anesthetics to ease the pain of childbirth was also opposed on religious grounds, until someone pointed out that the merciful Lord put Adam into a deep sleep before he took a rib to make Eve. The present opposition to nuclear energy has more sophisticated grounds based ultimately on Fear, Ignorance, and Prejudice. The present series, therefore, is dedicated to the dissipation of fear through the substitution of knowledge for ignorance and rational judgement for prejudice.

Concern for the state of man's environment is not new. The naturalist John Muir was concerned for the fate of the California Redwoods, and did something about it. Theodore Roosevelt was one of America's first conservationists.

His distant cousin, FDR, encouraged the planting of shelter-belts in the plains states during the dust bowl days. In 1950, a book titled Water, Land, and People was published that warned against "...our growing water famines, and floods, and the human consequences..." The present generation is no stranger to the flood of invective directed against the use of nuclear energy and warning of the dire consequences of its exploitation.

What the public does not know, for the simple reason that no one has troubled themselves to tell it, is that there is a vast reservoir of balanced factual information on the risks, the hazards, and the benefits of nuclear energy as a substitute for human muscle and sweat. Unfortunately, much of that information is buried in the dusty files of technical libraries. More recently, however, comprehensive reviews of the findings and conclusions of research groups and investigative committees have been published. Copies of those publications should be in every public library. If they are not, library users should insist that their libraries get them. A list of suggested titles will be given at the end of this article.

Most people do not have time to plough through such a mountain of printed material. For that reason, this series has been written to acquaint the public with the salient facts concerning nuclear energy to the end that they might make for themselves rational judgements on issues relating to nuclear energy. The source material has consisted, in part, of the publications described below, and in part, of personal experience in energy-related endeavours, such as geophysical explorations for oil, petroleum reservoir production research, and nuclear reactor physics research.

Nuclear reactor safety has been high on the list of priorities for nuclear research ever since the days of the first nuclear pile that was built under the West Stands of Stagg Field, University of Chicago, and that first demonstrated the possibility of a nuclear-chain reaction, on December 2, 1942. Multimillion dollar programs at the INEL that are devoted entirely to reactor safety research are the Power Burst Facility (PBF) and Loss of Fluid Test (LOFT) programs. Individuals, research teams, study groups, and commissions have studied the problem and issued reports. Some of the resulting conclusions will be presented in subsequent parts of this series.

The remaining parts of this series will discuss such questions as natural and man-made radiations, the risks and benefits of nuclear energy, waste products from nuclear power plants and from alternative power sources, power costs, and reactor safety.

The following list of publications should be in every public library for the use of community residents wishing to obtain first hand information on nuclear energy issues:

(1) Sourcebook on Atomic Energy, by Samuel Glasstone; D. Van Nostrand Co., Inc. (1967)

(2) New Energy Technology, by H. C. Hottel and J. B. Howard; MIT Press, Cambridge, Mass. (1971)

(3) Energy Alternatives: A Comparative Analysis, a report of the Science and Public Policy Program, University of Oklahoma, Norman, Oklahoma. (May, 1975) U. S. Supt. of Doc. Cat. No. PREX 14.2: EN2

(4) Report of the President's Commission on the Accident at Three Mile Island. (Oct. 30, 1979)

(5) Hearings Before the Subcommittee on Energy Research and Production of the Committee on Science and Technology, U.S. House of Representatives, Ninety-Sixth Congress, First Session. (May 22, 23, 24, 1979)

(6) Annual Review of Energy, Vol. 2 (1977), Vol. 3 (1978), Vol. 4 (1979), Annual Revs. Inc., Palo Alto, California.

(7) Energy: The Next Twenty Years, Rpt. of A Study Group, Ford Foundation, Hans H. Landsberg, Chmn., Bollinger Publ. Co., Cambridge, Massachusetts. (1979)

(8) Access to Energy, a monthly newsletter edited by Prof. Petr Beckmann. Access to Energy, Box 2298, Boulder, Colorado 80306.

Part 2 of a Series - Radiation

Radiation is Nature's method of moving energy from place to place. It is a dynamic rather than a static business. Static means that it is just there — it is not going any place. Dynamic means that it is on-the-move. If you detect any radiation of any kind, then it must have come from some place and it must be going some place else.

Just as all people are human, all radiation is electromagnetic energy. And like people, it comes in all shapes and sizes and colors. In empty space, all radiation travels at the same speed, always, everywhere; namely, the speed of light, 186,000 miles per second. In the presence of matter, it is slowed down; how much depends on the kind of radiation and how much matter is present.

It was thought at one time that neither energy nor matter could be either created or destroyed. In a sense, that idea is still true, but it needs to be changed a little. Matter cannot be destroyed, that is, changed from existence to non-existence; nor can matter be created out of nothingness. It can, however, be changed from matter to energy. Similarly, energy has been observed to be changed into matter, although on a very, very much smaller scale. The generation of electricity in a nuclear power plant depends on the changing of matter into energy, according to the equation proposed by Einstein,

$$E = mc^2.$$

The human organism is no stranger to radiation (radiant energy). Visible light is radiant energy; ultra-violet (not visible) light is radiant energy; infra-red (heat) light is radiant energy. The 60-cycle current that lights your home, and that toasts your bread produces radiation. Radio waves that bring you Bob Hope and Fred Sanford are a form of radiation. X-rays that find broken bones are radiation. Gamma rays that detect flaws in faulty welds in metal are radiation. These are all the good things that radiation does for people when kept under control. But just as fire in the fireplace will keep you warm on a cold winter's day, it will burn your house down, if it gets out of control.

Radio waves in a microwave oven will cook your food, and in a diathermy machine, they can produce an artificial fever to combat disease. Light is essential to vision, but laser light can cause blindness. Ultra-violet light manufactures vitamin D in your skin, but too much can cause sunburn and eventually, sometimes skin cancer.

Gamma rays are the bad actors produced when fission products decay by radioactive disintegration. Fission products are the ashes produced in a nuclear power plant. These are the radiations that frighten everyone out of their wits. But not everyone, really. Power plant workers respect gamma rays, but they don't fear them, because the workers know they have the gamma rays under control.

To understand why gamma rays are dangerous, whereas radio waves are not, it is necessary to get just a little bit technical. The degree of danger depends on the frequency of the radiation and on how much of it there is. The frequency relation is

Energy equals a constant times frequency.

The "constant" in that phrase is a very small number known as Planck's Constant, after a German physicist who discovered the relationship.

The power line current that toasts your bread has a frequency of 60 cycles per second and the radiated energy is very small. The radio waves that bring you AM programs have frequencies between 500,000 and 1,500,000 cycles per second, but the energy content is still small because Planck's Constant is small. FM radio waves have still larger frequencies. X-rays and gamma rays have frequencies so large that the energy content is appreciable, and it doesn't take much gamma radiation to produce significant damage.

Radiant energy from the sun sustains life on earth. The Solar Flux (radiant energy) contains all kinds of radiation, plus atomic particles. Much of that radiation is lethal to life, and the earth's atmosphere and magnetic field protect plant and animal life from it. The magnetic field deflects and traps high energy particles and the atmosphere absorbs ultra-violet light and gamma rays. The Kennely-Heaviside ionic layers responsible for long-range radio communication, and the Van Allen radiation belts are the consequence of that absorption and trapping of lethal radiation.

Besides the sun and nuclear power plants, there are other sources of radiation. Of the ninety-two naturally occurring elements, several are radioactive and emit both particle and radiant energy. Radium that is used on luminous watch dials is well known. Thorium that is used in your Coleman camp-light gas mantles is another. Tritium, a variety of hydrogen, is a weakly radioactive material found in rain water and is produced by the action of cosmic rays on water in the atmosphere. Carbon-14 is also produced by cosmic rays and is contained in all living matter. That is the stuff used to date archeological finds. Potassium, an element essential to life, is also weakly radioactive and emits radiant energy.

Does all this frighten you? It is not meant to. It is meant to show that all the earth and all life from the day of creation have been bathed in radiation. There is no escaping it, and in spite of, perhaps because of it, man has progressed from savagery to his present high state of civilization.

The dangerous forms of radiation can be controlled just as man has controlled fire. In the next part of this series, we shall talk about fission products, the nuclear ashes, and how they can be an alternative energy source.

Part 3 - Reactor Safety

At a meeting in November, 1974, Ralph Nader posed a question to the then AEC Commissioner, Doub,

"How many atomic explosions in our cities would you accept before deciding that nuclear power is not safe - no complexities, just a number?"

This is the kind of under-handed needling the anti-nuclear lobby engages in to frighten the American public. It is akin to the infamous trick question, "Do you still beat your wife?" Nader's question reveals an abysmal ignorance of nuclear technology, is based on a false assumption, and is deliberately provocative in tone. The phrasing of the question implies that there have already been atomic explosions in nuclear power plants; it assumes that an "atomic explosion" in a nuclear power plant is possible - a false assumption, and the insistence on "just a number" denies the respondent the opportunity of giving a rational answer.

It is necessary to place the whole question of reactor safety in the proper perspective, if the American public is to gain a rational understanding of the place of nuclear energy in the national economy. As pointed out by Petr Beckmann in his book, The Health Hazards of NOT Going Nuclear, "There is no such thing as safe energy conversion on a large scale; it is almost a contradiction in terms. Energy is the capacity for doing work, and as long as man is fallible, there is always the possibility that it will do the wrong kind of work." This article, therefore, will examine the questions of just how safe is nuclear energy compared to the safety of other human activities.

The National Safety Council collects statistics on all kinds of accidents in the United States. From a count of the number of accidents in a year, the probability of accidental death in that population is calculated. Attempts to calculate that statistic for the nuclear power industry met a very serious difficulty; there have been no accidental deaths in the nuclear power industry, ever. The Atomic Industrial Forum, however, rushed in where the National Safety Council feared to tread, and came up with an estimate that is about the same as the probability of being killed by being struck by a meteorite. These, then, are the statistics that have been collected:

One death per year per 7700 population in the home.
One death per year per 4000 population by automobile.
One death per year per 100,000 population by aeroplane.
One death per year per 5,000,000,000 population in a nuclear power plant.

In all fairness, however, it should be mentioned that there have been a few accidents in the nuclear program as a whole. Included are nuclear reactor research, nuclear power research, development, and construction, military reactors, and weapons development programs. Even so, the over-all safety record, including non-nuclear related accidents, is unequaled by any other industry, or class of industries as may be confirmed by consulting the collected data of the National Safety Council. In the early days of atomic energy, there were a couple of nuclear-related deaths, and there was one steam explosion in Idaho that killed three military personnel. But there have been no such incidents in either the commercial nuclear power industry or in the Navy's Nuclear Propulsion Program.

At this point, it is instructive to consider the nature of nuclear explosions as compared with other kinds of explosions.

Gasoline in combination with the right air mixture explodes inside your auto's engine to produce power to drive your car.

Firecrackers explode when their powder inside them burns rapidly.

The powder inside a 30-06 rifle shell explodes and drives the bullet when a hunter shoots a deer.

The uranium in an atom bomb fissions in a chain reaction and explodes under the right conditions.

Steam boilers and steam locomotives have been known to explode when the steam pressure accidently exceeds the ability of the boiler walls to hold it.

In the above recitation, one notes three different kinds of explosions: the gasoline and the powder in firecrackers and rifle shells represent chemical explosions, the steam explosions are due to the mechanical failure of the containment vessel, and the atom bomb was the result of a nuclear chain reaction. The first two events elicit scarcely a ripple in the public's consciousness; the third event sends shudders of horror up-and-down the public's spine at the mere suggestion. The steam explosion in Idaho that killed three service men was indeed the result of a nuclear power burst, but it was not a nuclear explosion. In fact, it is very difficult to produce a true nuclear chain-reaction explosion, so difficult that nuclear power reactors can and are built in such a manner that a chain-reaction explosion is impossible.

The discussion so far has dealt with the issue of the probability and consequences of a nuclear-related accident. There is also much concern with the exposure of personnel to radiation under normal conditions. The earliest experimental nuclear reactors sometimes left much to be desired in the way of shielding - not so, now-a-days. Today's nuclear power reactors are contained within several vessels of different kinds for different purposes. An inner steel pressure vessel contains the core and cooling liquid. The latter also provides some shielding. High-density concrete is used to provide maximum shielding against gammas, and neutron absorbers are used to shield against neutrons. Thus, the exposure of nuclear power plant workers is no worse than that of anyone working inside a concrete building.

The waste management issue, including environmental releases, will be examined in the part on Fission Products

A comprehensive treatment of what is needed to insure the safe operation of a nuclear power plant may be found in either of two publications. The report of the President's Commission on the Three Mile Island accident and Admiral Rickover's testimony before a Congressional Committee were referenced in Part I of this series. The following quotations from these documents provide factual answers to the issue of reactor safety.

From the Report of the President's Commission:

"The purpose of the Commission is to conduct a comprehensive study and investigation of the recent accident involving the nuclear power facility on Three Mile Island in Pennsylvania."

"To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices -- and above all -- in the attitudes of the Nuclear Regulatory Commission, and, to the extent that the institutions we investigated are typical, of the nuclear industry."

"But as the evidence accumulated, it became clear that the fundamental problems are people-related problems and not equipment problems."

"A comprehensive system is required in which equipment and human beings are treated with equal importance."

"We are convinced that if the only problems were equipment problems, this Presidential Commission would never have been created."

In contrast with the subject of this report of the President's Commission, Admiral Rickover's testimony recounts the history of a highly successful operation. The following are some quotations from the referenced document.

"In the 26 years since the Nautilus land prototype first operated, which was in 1953, there has never been an accident involving a naval reactor, nor has there been any release of radioactivity which has had a significant effect on the environment."

This statement becomes all the more impressive in view of the magnitude of the Naval Nuclear Propulsion Program.

"Today, 115 nuclear-powered submarines are in operation; 41 of these are ballistic missile firing submarines and 74 are attack submarines; 23 additional attack submarines and 7 Trident submarines are authorized for construction."

"We also have one nuclear-powered deep submergence research and ocean engineering vehicle. Three nuclear-powered aircraft carriers are in operation and one more is being built. Eight nuclear-powered cruisers are in operation, and one more is being built. Altogether, 127 nuclear-powered ships are in operation."

"Since the U.S.S. Nautilus first put to sea in 1955, Naval nuclear-powered ships have steamed over 40 million miles and have accumulated over 1,800 reactor-years of operation. We have procured 508 nuclear cores and have performed 166 refuelings."

In his testimony, Admiral Rickover explains in great detail the policies and procedures employed to accomplish the above described record. He himself recognizes that not all the methods employed in the Naval Nuclear Propulsion Program would be applicable in industry. Never-the-less, the inescapable conclusion must be that, "If the Navy can do it, there is no reason why industry cannot do as well."

Part 4 - Fission Products and Wastes

Much of the nuclear power controversy revolves around the disposal of wastes. The generation of electricity in nuclear power plants results in four classes of materials that are generally classed as waste because they do nothing to produce more electricity; they are apparently of no value to anyone. Such is the opinion of the general public, but that is not strictly in agreement with reality, as the following discussion will show.

The first class may be called simply "nuclear dirt." Included are contaminated articles that have picked up radioactive particles during their use in construction or repair, or were used some way in the handling of radioactive materials. The situation is much the same as the one in which an auto-mechanic would throw away his wrench because it was greasy. This waste is bulky, but the radiation level is low.

Another source of so-called waste consists of corrosion products and neutron activation products in the process water, particularly in the case of the Boiling Water Reactors.

Fission products and elements heavier than uranium (the transuranic elements) constitute the third and fourth classes.

At present, the "nuclear dirt" is stored in plastic bags which are in turn sealed into steel drums. A final disposition of this material is yet to be decided.

Materials of the second class are partially vented to the atmosphere when the activity is low enough. Some are injected into deep wells. All of these methods have come under fire from environmentalists and the matter is yet to be resolved. However, a study of effluents from the Shippingport reactor during the period 1957 to 1971 concluded that it was impossible to determine whether the discharge of radioactive materials to the environment was "...in part responsible for increased cancer incidence, infant mortality, and heart disease in the population living in the vicinity."

An isotope of great concern to many is tritium, a variety of hydrogen. Tritium is produced in reactors by the neutron bombardment of deuterium, another variety of hydrogen. It is also produced by the action of cosmic rays in the upper layers of the atmosphere. Large amounts appeared in rainwater as a result of the bomb tests that were made during the 1950's. The concentrations dropped back to normal levels, however, within a few weeks following the tests. Research has shown that because of the short half-life (12.3 years) and the long time taken for rainwater to reach water wells (40 to 50 years), the tritium drops to about 6% of the original content by the time water is drawn from a well.

Thus, the deeper the well, the smaller the residual tritium content.

This leaves the fission products and the transuranic elements. The fission products are atoms about half the size of a uranium atom produced when the latter splits up during the fission process. There are over two hundred species of such atoms, since not all uranium atoms split in the same way when they fission. Half-lives of these products may be anything from small fractions of a second for some species, to many years for other species. All are either gamma or beta ray emitters, or both. A very few are alpha emitters.

Nuclear fuel elements are constructed in a manner calculated to retain all the fission products (the nuclear ashes) sealed inside. Many fission products are strong neutron absorbers; hence, a point is reached such that the fission products absorb all the neutrons and the chain reaction can no longer be maintained. There is still a large amount of unconverted uranium in the fuel element that can be recovered. At present, spent commercial fuel elements still contain 70 to 80% of unconverted uranium. Yet they are not reprocessed, presumably for political reasons. Only military and research cores are reprocessed. Research on the disposition of these separated fission products has shown, however, that they can be safely packaged and may even prove to be a source of low potential heat, for some low-energy density applications.

At present, fission products are reduced to a granular kind of material, resembling somewhat a coarse salt. This material generates heat from the radioactive decay process and must be cooled to prevent possible escape of some of the hazardous material. A more permanent disposition consists of casting the fission products in a pyrex-like glass in sealed stainless steel cylinders. In this form, fission products could be stored safely for an indefinite length of time. The only drawback is that cooling would have to be provided. Current research is directed toward the goal of finding suitable crystal structures in natural or synthetic materials that would accept the fission products within the crystal lattice. This process is similar to fitting round pegs in round holes, thus producing a more stable bond between fission product and host crystal structure.

The necessity of supplying cooling suggests a practical use of this supposedly waste material. The gamma heat produced by one cubic meter (a little more than a cubic yard) has been calculated to be sufficient to provide space heating for four average homes for one hundred years. The domestic application is probably impractical, but certainly space heating of large public buildings is a practical possibility. Public acceptance is all that would be required.

For the present, and except for plutonium-239, the transuranic elements are more of a nuisance than a hazard. They can be stored in the same way as other fission products until such time as some practical use for them is discovered.

Plutonium is another story. One often hears the remark, "There is no known way of disposing of the plutonium-239." The obvious answer is "Put it in a reactor and generate some electricity with it. Then it will no longer be plutonium, but fission products for which safe storage methods are known."

In spite of the Shippingport study mentioned above, there have been additional complaints of the discharge of radioactive wastes to the environment. A detailed study of liquid and gaseous releases to the environment, including the Shippingport study, was published in 1976 (Nuclear Power Safety, by Rust and Weaver, Pergamon Press, New York). The conclusion was that radioactivity releases did not exceed standards that have been set. The controversy, however, is still raging, and studies are continuing, not only of effluents from nuclear plants, but from other sources, as well. Detailed information of pollution levels from all sources can be obtained from the National Climatic Center, Federal Building, Asheville, North Carolina 28801.

Nuclear power plants are not the only sources of pollutants. Recent news articles about the genetic damage resulting from the dumping of chemical wastes in the Love Canal area have alerted the public to this fact. In this article, only waste products generated by coal-fired power plants will be considered, because coal is the alternative usually recommended.

When coal is burned in boilers to produce steam for turbo-electric generators, the following waste products result:

12 tons of ash per 100 tons of coal burned
242 tons of carbon dioxide per 100 tons of coal burned
1.7 tons sulfur dioxide per 100 tons of coal burned (low sulfur grade)
6.1 tons sulfur dioxide per 100 tons of coal burned (high sulfur grade)

At 30% efficiency, 100 tons of coal yields 186,000 kiloWatt hours. Hence, a 1000 megaW coal-fired power plant would burn 537 tons of coal per hour. Other toxic materials found in the coal ash are selenium, mercury, vanadium, and benzopyrene, among others. Radioactive materials found in coal ash are radium and thorium. The major impact on the environment, however, is due to the carbon dioxide and the sulfur dioxide. When sulfur dioxide dissolves in water, one gets sulfuric and sulfurous acids. Thus, one gets the acid rain that one has been reading about in recent newspapers. A more far-reaching, long-term and, therefore, uncertain effect is that due to the carbon dioxide. Research reported in the Journal of Geophysical Research for June 20, 1979, estimates that a one hundred percent dependence on coal would raise the global average temperature by 9 degrees Centigrade, by the year 2100. This temperature increase is attributable to the "Greenhouse Effect" caused by the presence of carbon dioxide in the atmosphere. Just what the long-term effects might be are not at all clear, simply because they are long-term and because of the complexity of the situation.

It appears, therefore, that any large scale development of energy sources of any kind can have serious consequences that are not at all easy to assess. It is important that the average citizen become informed of the nature of the problems. It is not necessary that one be knowledgeable in all the details of all possible energy alternatives. What is needed is a sound understanding of some of the general principles.

Part 5 - Energy Costs

Cost considerations go far beyond the quoted rates at which electricity is sold in cents per kiloWatt-hour. Whether an energy source is economical also depends on how much energy is expended in producing the energy delivered to the consumer.

An article in the December, 1974, issue of the Smithsonian discusses the question of how much energy is needed to produce the energy currently being used, and concludes that the present energy economy has reached the point of diminishing returns. That is, the energy return for a given energy input is becoming progressively smaller.

According to Reference 3, 2 percent of the energy in the mined coal is used to mine, transport, and prepare the product for sale. Further processing might involve any of several coal-gasification or coal-liquefaction processes having efficiencies ranging from some 55 to 85 percent. This means that the convenience of a liquid or a gaseous fuel over a solid fuel has cost from 15 to 45 percent in energy costs.

For nuclear fuels, the energy cost from mining, ore concentration, uranium smelting, fuel enrichment, to fuel element fabrication is about 10%. Thus, coal has an energy cost advantage of 2%, as compared with 10% for nuclear energy.

The over-all energy efficiencies for both coal and nuclear power plants have been estimated in this same publication as follows:

32% for light water moderated nuclear reactors

38 to 40% for coal-fired power plants

The difference is attributed to the higher operating temperatures of the coal-fired plants.

In the above analysis, fuel costs only were considered; eventual dollar costs to the consumer include, in addition, capital equipment, energy transportation, and distribution costs. These latter items are currently in such a state of flux that any estimate of current values would have little more than a historical interest. Interest rates and inflation influence the dollar costs of the three items listed above, all of which leads industry to bring pressure to bear on regulatory bodies to increase service rates.

Dollar costs and dollar savings through the use of nuclear power have been estimated by the Atomic Industrial Forum and by the Westinghouse Corporation for the years 1976, 1977, and 1978.

Coal in 1976, 1.8 cents per kiloWatt hour
Oil in 1976, 3.5 cents per kiloWatt hour
Nuclear in 1976, 1.5 cents per kiloWatt hour
Coal in 1978, 2.3 cents per kiloWatt hour
Oil in 1978, 4.0 cents per kiloWatt hour
Nuclear in 1970, 1.5 cents per kiloWatt hour

Dollar savings through use of nuclear power in 1977 have been estimated as follows:

Wisconsin	$ 8.00 per year
Philadelphia	$ 16.00 per year
New England	$ 180.00 per year
Baltimore	$ 81.00 per year

These figures, as already stated, are of little more than historical value; cost forecasts vary. Current construction and equipment costs amount to 70% of the cost of nuclear-generated electricity; for coal-fired plants, the cost is 35 to 65%. The use of scrubbers to remove the fly-ash will increase this latter figure. Predictions of construction costs per kiloWatt in 1986 are $800-$1000 for coal-fired plants, $1000-$1300 for nuclear plants.

Hottel and Howard (Ref. 2) have calculated that it is cheaper to transport energy as coal than as electricity. It would appear, then, that coal-fired generating plants should be built near to usage areas. The waste problems associated with coal would seem to indicate the opposite, with the energy transported by electricity. The convenience of electricity is probably worth the added cost. Similar considerations probably apply to nuclear power plants.

Most experts agree that coal and nuclear energies will be the major sources in the near future (20 years). Other alternatives will require that time for commercial development, if indeed they are commercially feasible at all.

On balance, therefore, coal and nuclear come out about as follows:

Long-term Abundance	Nuclear equals coal
Public Acceptance	Coal beats nuclear
Initial Capitalization	Coal beats nuclear
Thermal Efficiency	Coal beats nuclear
Waste Problems	Nuclear beats coal
Environmental Impact	Nuclear beats coal
Ultimate Consumer Cost	Nuclear beats coal

Part 6 - Risks and Benefits of Nuclear Energy

The evening news on TV stations in Idaho Falls on June 8, 1980, announced that there was a 99% chance that the northwestern states of Washington, Oregon, and Idaho would suffer a severe power shortage within the next couple of years. Some industries would be forced to shut down, workers would be laid off, and residents would be without electricity for several hours out of a day. The same news item stated that the construction of several nuclear power plants had been delayed by construction and labor problems; and some others by people objecting to their construction. Some that have been planned may never be built, and those under construction may not be completed for another ten years.

This situation was brought about by objections raised by people who themselves have admitted that they know nothing about nuclear energy. These objectors (intervenors in legal language) have claimed that nuclear power plants are inherently unsafe, by which they mean that there is no way to make them safe. The fallacy in their reasoning is in the intervenor's interpretation of "safe." By safe, they mean "zero risk."

Before discussing risks and benefits, however, it is instructive to quote from Admiral H. G. Rickover's testimony before a Congressional committee...

"The human body is God's finest creation, and yet we get sick. If we cannot have perfect human beings, then why should we expect, philosophically, that machines designed by human beings will be more perfect than their creators? ...This is what many unthinking people demand, even though the Lord himself did not reach this height."

Risk is defined as the product of the probability of an event, and the consequences of that event. When someone says he took a calculated risk, it means that he estimated the likelihood of the event and multiplied that by the seriousness of the consequences if that event occurred. If the probability of getting caught speeding is 50% and the fine is \$50.00, then if you could afford to pay the \$50.00 fine, you would speed only one-half of the time. If you could afford to pay a \$100.00 fine, then you might speed 100% of the time. Thus, you balance the risk against the benefit. In this case, the benefit being getting to your destination sooner.

In the present instance, the benefits are an abundant, cheap, clean, and the safest known source of energy devoted to the service of mankind.

The risks are minimal as compared with those associated with the use of coal, as pointed out in the previous part of this series. It was shown that the disposal of radioactive wastes and fission products is a problem that has been solved technically; public acceptance is all that is still needed. The history of the Naval Nuclear Propulsion Program proves that nuclear energy is not the dreadful ogre pictured by the intervenors. The American people need to recognize that, like the family automobile and the aeroplane, the nuclear power reactor is a very dangerous device to fool around with, but also like the automobile and the aeroplance, it can be controlled, just as man controls fire.

We are lucky that Ralph Nader did not know, when Henry Ford was inventing the T-model, that 50,000 people would be killed annually in auto accidents in the United States at a cost of 34 billion dollars, or he would never have permitted Henry Ford to build such an unsafe device. Certainly, the Wright brothers would not have been allowed to invent their aeroplane, if Ralph Nader had known that about 1,000 people would be killed annually in aeroplane accidents.

The American public must not let angry little people deflect their attention from the real issues. The real issues should be resolved by rational judgement based on factual knowledge, rather than on Fear, Ignorance, and Prejudice.

CITIZEN EDUCATION ON NUCLEAR

TECHNOLOGY

IV-ECONOMIC UNIT

"It is true that economics is a theoretical science, and as such, abstains from any judgement of value."

Ludwig von Mises

INTRODUCTION

The conversion of a fuel source to useable energy is full of hidden and not-so-hidden energy (and therefore economic) costs. Mining of coal or uranium and drilling of oil, processing, transportation to the power plant, operation of the plants, and disposal of wastes all take energy. The equipment that does these jobs all took energy to be produced. Deeper drilling and farther distances consume more energy. As easily accessible fuels have been mined or drilled, more energy has been required to obtain the same amounts of less-accessible supplies. Off-shore drilling and Alaskan oil fields are two examples of the vastly increased difficulty of obtaining resources, as well as of the tremendous amount of energy needed to get them to the power plant.

The principal alternatives to nuclear power for large scale generation of electricity are the fossil fuels - coal, oil, and gas. Of these, gas is the least air polluting, but its supplies are limited for long-term planning, and rely to a great extent on foreign markets. Low sulfur oils also depend on foreign markets with all that implies in uncontrollable costs and the vagaries of foreign relations.

Large domestic supplies of coal seem to be the logical answer, but the economic (as well as, and largely because of, environmental impact) costs of coal are high. Damage to the land of many states has resulted from essentially unrestricted strip mining. Legislation to require reclamation of the land increases the cost of mining. The environmental unit surveyed the environmental costs of burning coal (as well as other fossil fuels). The economic costs to control these impacts are very high. In fact, some areas already assaulted by fossil-fuel power generation wastes, industrial air pollution, and auto emissions, have banned the construction of new fossil-fueled power plants.

Another factor to be considered from an economic viewpoint is the tremendous amount of water that would be required for large scale conversion of coal to gas or steam, or the release of oil from shale. In 1974, the

National Academy of Sciences said there might be enough water in the West to mine the coal, but large scale conversion is beyond the capability of the dry Western States. The gathering, transport, and disposal of these tremendous amounts of water, even if it were available, requires energy and would be extremely expensive. The conversion processes are expensive and take energy. In 1974, according to Wilson Clark ("It Takes Energy to Get Energy," Smithsonian, December, 1974), at least one major oil company decided not to bid for federal leases to develop oil shale because the net energy yield was too small.

POWER PRODUCERS

Stockholder-Owned Public Utilities

Approximately 79% of the electricity generated in the U. S. is produced by investor or stockholder-owned public utilities. These companies are owned by individuals, through the purchase of stock, like other companies, but they are public utilities. As such, they are given a monopoly to provide service in a particular area, and, in return, agree to have rates, service, and settlement of customer disputes governed by the state.

As with other stockholder-owned businesses, public utilities must operate at a profit if their stock is to be attractive to the potential buyer. Utility rates provide about 25% of the capital for expansion and maintenance. The remainder comes through sale of stocks, bond issues, and loans.

Federal Agency Produced Power

The most famous of the federal power agencies is the Tennessee Valley Authority. It is a wholly-owned government corporation which serves the southeast states with flood control projects, navigation channels on the Tennessee River, electric power production, fertilizer development, recreation, and forestry and wildlife programs.

The electric power program is financially self-supporting. TVA acts as wholesale supplier to 160 municipal and cooperative electrical systems, with 2.6 million customers. Power is supplied from 29 dams, 12 coal-fired plants, 2 nuclear plants, 4 combustion turbine installations, 8 U. S. Army Corps of Engineers dams, and 12 Aluminum Corporation of America dams.

Another form of federal agency in the power field is the Rural Electrification Administration, which was founded in 1935 to finance electric and telephone facilities in rural America and its territories. Over 1000 rural electrical systems have received self-liquidating loans and technical assistance for the construction and operation of generating plants and transmission facilities.

The federal government also has a number of Power Administration Agencies which market power produced at other federal facilities as well as private generating plants. The Southeastern, Southwestern, and Western Area Power Administrations are examples of these.

In the Northwest, the Bonneville Power Administration (BPA) markets the power for twenty dams built and operated by the U. S. Army Corps of Engineers and nine dams built by the Bureau of Reclamation. BPA also markets nuclear power from the Hanford and Trojan plants. Its transmission system serves as the backbone grid for all Northwest utilities and it provides more than half the total electricity used.

The BPA was formed in 1937 as a Bureau of the Department of Interior and is now a part of the Department of Energy. It serves Washington, Oregon, Idaho, and parts of Montana, California, Nevada, Utah, and Wyoming, or an area of 300,000 square miles and seven million people. Its customers include municipalities, public and utility districts, cooperatives, private utilities, government agencies, and industries.

Funds required to build, maintain and operate the dams are appropriated by Congress. Since 1974, BPA has financed its operation and maintenance from revenues; revenues have also financed part of the construction of new transmission facilities, with the remaining funds coming from the sale of revenue bonds. BPA revenues also pay for part of the cost of large irrigation projects.

BPA rates are set by its staff after review by the Department of Energy and approval by the Federal Energy Regulatory Commission. The rates must recover to the Government the cost of producing, purchasing, and transmitting electricity, as well as repay capital investments with interest. The rate-setting procedure includes meetings with customers. Adjustments in rates have generally been given every five years, with yearly adjustments to begin in 1980, because of sharply increasing costs.

Mix of Locally Produced and Wheeled Power

Private industry and various levels of government, as we have seen, are all in the energy production business. Government operations range from the low head bulb turbine project for the City of Idaho Falls to the Tennessee Valley Authority in the southeastern U. S.

Electricity is transmitted over networks called "grids" which combine and distribute electricity from a variety of sources through a large geographic area.

Every area differs as to the amounts of electricity it receives from the various sources. In the case of Idaho Falls, since the Teton Dam flood in 1976, the municipal generating capacity has produced about 5% of the electricity used by city customers. The remaining 95% is purchased from BPA. After the low head bulb turbine project is completed, Idaho Falls will be able to produce approximately 20% of its electricity.

The area of Bonneville County surrounding Idaho Falls is serviced by Utah Power and Light, (UPL) a private utility. UPL produces its own electricity. Ninety-five percent of its generating capacity is coal-fired, with about 5% coming from hydro-electric facilities in the Bear River area.

113

POWER COSTS

Table IV-1 lists the distribution of energy demand among the various sources and users. A cost breakdown for electricity generation is also given.

Table IV-1

Distribution of Sources and Users

Source: United States Energy Data Book, 1979, The Institute of Electrical and Electronics Engineers, Inc.

Use of Energy in the U. S. in 1977

Coal	18.6%
Oil (46% imported)	48.8%
Gas	25.8%
Hydro	3.2%
Nuclear	3.6%
	100.00%

U. S. Energy Use - 1977

Source	Resid.	Comm.	Indust.	Trans.	Total
Coal	4.9%	3.0%	10.2%	0.5%	18.6%
Oil	6.0	5.8	10.4	26.6	48.8
Gas	8.0	4.5	12.5	0.8	25.8
Hydro	1.0	0.7	1.4	0	3.2
Nuclear	1.2	0.8	1.5	0.1	3.6
	21.2%	14.8%	36.0%	28.0%	100.0%

Electricity Generation Costs - 1977***
(Commonwealth Edision)

¢/kWh

	Fuel	Operation & Maint.	Capital Charge	Total
Nuclear* System Avg.	0.35	0.22	0.76	1.33
Coal** System Avg.	1.21	0.30	0.90	2.41

*Nuclear includes allowance for carrying charge of fuel in reactor and ultimate waste disposal.

**Coal includes allowance for carrying charge of a 90-day coal stockpile.

***Source of electric generation cost figures: Science, Vol. 20 (Rossin & Rieck) August 18, 1978.

110

Relative Power Costs

Table IV-2 gives some relative costs of electricity. Table IV-3 shows savings to consumers. Table IV-4 shows the percentage of electric power generated by nuclear plants, May, 1978.

Table IV-2

National Electricity Generation Costs

	1976	1978
Coal	1.8¢/kWh	2.3
Oil	3.5	4.0
Nuclear	1.5	1.5

(Sources: 1976 figures from Economics of Nuclear Power, Westinghouse Corporation; 1978 figures from Time-Related Nuclear Plant Capital Costs, Westinghouse Corporation)

The cost of generating electricity in nuclear facilities remained stable, while the cost of fossil-fuel generation has been increasing. Utilities using both nuclear and fossil-fuel facilities have estimated that dollar savings to their customers have occurred because of the availability of nuclear power.

Table IV-3

1977 Cost Savings to Typical Residential Customer Because of Nuclear Power

Wisconsin	$ 8
Philadelphia area	$ 16
New England	$180
Baltimore	$ 81

(Source: Atomic Industrial Forum and Westinghouse Corporation)

In 1976, Connecticut consumers received a $21.5 million rate reduction, because of the heavy reliance of Connecticut utilities on nuclear power. The utility which provides power to the Metropolitan Chicago area estimates that its nuclear plants produce electricity 25% more cheaply than low-sulphur coal-fired plants.

Table IV-4

Percentage of Total Electricity Generated by Nuclear Plants in Leading Nuclear Power States; May, 1978

Connecticut	56%
Nebraska	47%
Vermont	44%
Maine	40%
South Carolina	36%
Minnesota	31%
Illinois	30%
North Carolina	30%
Wisconsin	29%
Arkansas	25%

(Source: Economics of Nuclear Power, Westinghouse Corporation)

Capital Costs

Initial construction and equipment costs amount to 70% of the cost of electricity from nuclear power plants, and about 35-65% of coal-fired plants (the use of scrubbers increases cost of construction). Predictions of construction costs per kW in 1986 are \$800-1000 for coal-fired plants, \$1000-\$1300 for nuclear plants. The cost of equipment is almost identical; however, because of licensing procedures, nuclear plants average an additional two years before construction begins.

Nuclear and coal will be the two main sources of bulk electric power for the foreseeable future (in most parts of the country). In regions with access to large deposits of low sulfur coal, coal will be more economical. Otherwise, nuclear power has an economic advantage.

Transportation Costs

The cost of transporting energy by various methods has been calculated by Hottel and Howard. A summary of their results is given in Table IV-5. Though they do not quote the cost of transporting fuel elements, it seems reasonable to suppose that it would be similar to coal by rail.

Table IV-5

Energy Transportation Costs

Transportation Method	Cost: Cents per million BTU per hundred miles
Electric highline (AC or DC)	8 to 18 cents
Coal by rail	3 to 8 cents
Coal by pipeline	1.5 to 3 cents
Oil pipeline	0.4 to 1.5 cents
Liquified natural gas	0.8 cents
Gas pipeline	1.0 to 2.5 cents
Oil by barge	0.4 to 0.7 cents
Oil by tanker	0.25 to 1.0 cents

Note: Range of costs due to different distances. Lower costs are for longer distances up to 1,000 miles. Higher costs are for distances of the order of 100 to 200 miles. Sources are given in the reference.

Tax Structure - Effects in Private Sector

There have been a number of studies of the fiscal, or economic, impacts of nuclear power plant construction and operation on communities. The study referred to in this section is, "Fiscal Impacts Associated With Power Reactor Siting: a Paired Case Study," by D. J. Bjornstad. The study was prepared for the U. S. Nuclear Regulatory Commission.

During the construction phase of nuclear facilities, the town will experience economic stress and boom -- these phenomena are discussed in the Sociological Unit. The primary effect after construction is in the public sector. This is true because the plant will employ relatively few people and buy relatively little in local goods and services. As a result, the economic impact of operating nuclear plants is on the tax base.

Property tax assessments of public utilities is extremely complex. In 29 states, including Idaho, a state agency is charged with assessments and only 11 states leave local assessors wholly responsible.

There have been few court tests or other appeals of tax rates set on nuclear facilities by assessors. The utilities don't want objections either to locating there in the first place, or to expanding. The towns, on the other hand, don't want to call attention to their situation.

At the time the study was prepared (mid 1970's), the Massachusetts and Connecticut legislatures were considering legislation which would have redistributed tax payments from power reactors on a statewide basis.

The Bjornstad study used a four-part framework to analyze the impact of nuclear plant property taxes. The first is the taxing ability of the community; what other sources of revenue? -- the degree to which that ability is used, or taxing effort; the uses to which the revenues are applied; and, the effect of tax expenditure decisions on the local economy. This framework can be used to determine the effect of additional tax dollars in any community.

In the two communities studied in the project cited earlier, local assessors are responsible for assesments. The communities studied were Waterford, Connecticut, and Plymouth, Massachusetts. In each case, property taxes were the primary local revenue source and in each case, those revenues approximately doubled. Both communities decided to reduce tax rates.

This decision is crucial. If the tax rate had remained the same, the community would have had additional funds to improve and/or to offer new services. By deciding to decrease the rate, the amount of local public revenue remains stable, and the local disposable income in the private sector (individuals and business) increases. This can lead to increased business activity and expansion.

Tax Structure - Effects in Public Sector

Lower Alloways Creek Township, in New Jersey, is a town which has used power plant taxes to pay for many improvements and services in the public sector. Budget surplus allowed the town, in 1979, to build a new fire station, new senior citizens center, and an addition to the school (which has a 13-1 pupil-teacher ratio). Main street was remodeled, a flood control project begun and roads rebuilt; all paid for with cash.

In earlier years, a new fire hall, municipal center, tennis courts, school additions and a police department were built. The town has also purchased a ski resort, which it plans to develop.

Other parts of the country have also benefited from the nuclear plant's tax payments, including three area hospitals.

There are no local taxes, though property owners pay a county tax of $1.40 per $100 of assessed value ($420 on a $30,000 home).

OTHER COST CONSIDERATIONS

Job Multiplier Effect

To the extent that new jobs are created and that these individuals live in the community, they use housing, retail goods, etc., and thus contribute to the economy, creating additional jobs. A Florida study found that each job created by the Martin nuclear plant facility resulted in 0.67 of a job in the community.

Old Power vs. New Power

No one needs to be told about the effects of inflation and extremely high interest rates on new construction. As long as these economic factors continue, the principal differences in costs of power generation will be between old and new power, rather than between coal, nuclear, oil, hydro, etc.

Costs of construction for all types of new power generation can be expected to continue to increase at a rapid rate. New and revised safety provisions for nuclear power plants will drive costs even higher. By the same token, the intention to burn more coal will bring increased demands from medical, scientific, environmental, and other groups to install scrubbers and other equipment.

As a result, it is impossible to project future costs accurately. Each new facility will need to be considered individually on its economic merits.

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CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY

V-POLITICAL UNIT

"I do not understand," said the
little prince.
"There is nothing to understand,"
said the lamplighter. "Orders
are orders. Good Morning."
And he put out his lamp.

Antoine de Saint-Exupery
The Little Prince

INTRODUCTION

"Political" as used in the present context refers to the manner in which a government deals with the nation's problems - in this case, energy problems. To have an "energy policy," it is presumed to mean that one has a plan of action based on the nature of the situation in question. Under normal conditions, the urgency to "adopt a policy" is minor, if not in fact absent. Under "crisis" conditions, the demands for "a statement of policy" become ever more strident. A crisis usually results whenever sources of supply, demand, costs, profits, distribution means, and the system in general get out of balance; in such a case, a "policy" is supposed to set everything right. Hence, the current demands on Congress and the President to devise an energy policy for the United States. At the present writing, the content of any such policy, assuming there is one, is not entirely clear - Is it to retain or remove controls? Is it to institute rationing? Is it to tax imports? Is it to promote the development of nuclear energy, or of coal as an energy source, or is it to prohibit such developments? Or is it a dozen other things one might imagine?

What one can say about the United States' energy policy is limited. The President's Commission on the Three Mile Island accident has made recommendations, and changes in the Nuclear Regulatory Commission and in industry's management of nuclear reactors are certain to be made. This unit, then, will discuss only current matters and these could be different by the time this material is printed.

NUCLEAR REGULATORY COMMISSION

The Atomic Energy Commission, for many years, was responsible for research and development of nuclear power and also for regulating its use by private industry. In 1974, these responsibilities were divided by the Energy Reorganization Act, which created the Energy Research and Development Administration (now further reorganized into the Department of Energy) and the Nuclear Regulatory Commission (NRC).

Within the NRC, several boards and committees deal with licensing of commercial power plants. The office of Nuclear Reactor Regulation analyzes the plant's design and operations procedures for safety. The Advisory Committee of Reactor Safeguards retains consultants and contractors to supplement its own staff of experts from various fields to advise the NRC. The Atomic Safety and Licensing Board is appointed by the NRC and consists of an attorney, who acts as chairman, and two technical members.

The federal, state, and local requirements for as many as 52 licenses are the major reason the licensing procedure takes so long for commercial nuclear plants (typically, 10 years). Many of these licenses are also required for other power-generating plants, and are related to land, water, and air impacts. There are no comparable federal licensing procedures for coal-fired or other fossil-fueled electric generating plants, however, or for hazardous chemical processing plants.

Licensing Procedures

Two licensing procedures are needed before a commercial nuclear facility can begin supplying electricity to customers. The first deals with design and construction; the second is an operating permit.

After a utility selects a site and an architect/engineer, it begins its construction licensing procedure with the Nuclear Regulatory Commission. A Preliminary Safety Analysis Report is filed, with information about design, location, safeguards, and a comprehensive environmental report. It also contains detailed safety factor calculations on all components, systems, and methods of calculation.

While the utility is preparing this information, the NRC holds the first of a series of public information meetings dealing with safety, environmental impact, location and type of plant, the regulatory process and the times for public participation in the licensing process. This process can take from one to three years.

After the application has been received by the NRC, a review process begins and copies of the application are placed in the NRC Public Document Room in Washington and in the area of the proposed plant. Copies of all other correspondence and documents are made available, also.

The review of the application is concerned with design methods and procedures, characteristics of the proposed location, evaluation of potential consequences of hypothetical accidents, proposed operating procedures, plans for emergency action, programs for quality control, and control of radioactive wastes. The process also verifies all the utilities' calculations independently. This review process takes from one to two years.

After the review has satisfied the NRC staff, a Safety Evaluation Report is prepared. During the review period, the Advisory Committee on Reactor Safeguards is also reviewing the application. If the ACRS raises any questions of safety, or if any additional information is available after the issuance of the Safety Evaluation Report, the NRC prepares supplementary reports.

The staff also completes an independent environmental review (with public hearings), issuing a Draft Environmental Statement for review and comments from federal, state and local agencies, as well as individuals and organizations. A final Environmental Statement is then prepared and issued.

A public hearing is then announced, at which time written and oral statements may be entered into the record. The hearing is conducted by the Atomic Safety and Licensing Board.

If, after all of this, a favorable decision is reached and approved by the Atomic Safety and Licensing Appeal Board and the NRC, a construction permit is issued. Some types of construction, such as site preparation, temporary construction support facilities, etc., may have already begun under a Limited Work Authorization, after the NRC has determined that there is a "reasonable assurance" that the permit would be granted.

Separate hearings are held to guarantee that the applicant is in conformance with anti-trust laws.

The process of gaining an operating license begins with submission of a Final Safety Analysis Report. It contains information on the final design of the facility, final safety factor calculations, and plans for operation and emergency procedures. The staff again reviews the application, prepares a Safety Evaluation Report and the ACRS makes another independent evaluation.

A public hearing is not required at this point. However, the NRC publishes notice that it is considering issuing the license and anyone may petition for a hearing.

If finally granted, the operating license contains Technical Specifications for the safety, environmental, and health measures which must be met. There are also hundreds of NRC and EPA regulations. The entire process, from site selection to operation, takes about 10 years, if there are no long delays.

Inspections During Operation

The NRC maintains inspection and enforcement programs during the construction and operation of the plant.

The Office of Inspection and Enforcement is charged with insuring that the utility operates the plants according to the provisions of its license. The Environmental Protection Agency and the NRC's Division of Reactor Licensing audit utility records. The insurance companies which provide pool coverage also inspect utility operations.

Citizen Participation

In addition to the federal public hearings and the public information meetings outlined earlier, state utility commissions also conduct public hearings. Individuals or organizations may have their interests/concerns/questions made a part of the record and considered during the decision-making process.

Under the structure which has been established, affected parties (those with a particular interest in a particular plant) may act as "intervenors," which means they may not only present testimony but also question the testimony of others as part of the proceedings.

Anyone dissatisfied with the decision of the licensing board may appeal, first to the Atomic Safety and Licensing Appeals Board and then, of course, to the courts.

Significant Court Decisions

There have been two cases which have interpreted and defined the responsibility of the Nuclear Regulatory Commission under the Energy Reorganization Act (1974), the Atomic Energy Act (1954), and the National Environmental Policy Act (1969).

The Calvert Cliffs decision required the AEC, and now the NRC, to prepare independent environmental impact statements and the Scientists' Institute for Public Information decision required the preparation of environmental impact statements on the impact of overall programs, including development programs as well as individual utility requests for plants.

Liability Insurance

The Price-Anderson Act (an amendment to the Atomic Energy Act of 1954) passed in 1957, established a system for insuring against loss from a nuclear generating plant accident. Prior to that time, private insurance companies had been reluctant to enter into the field because of no experience and lack of capacity on the part of individual companies.

Homeowners' insurance generally contains clauses which limit their liability - these limitations include earthquake, flood, waves, land and mudslides and nuclear damage. In the case of the nuclear exclusion, the reason is to channel all such claims through the mechanism set up by the Price-Anderson Act. All legal proceedings are joined before one federal court, to insure uniformity of legal treatment of claims. The injured party must prove the amount of damage and that it occurred because of a nuclear accident. The coverage of the Price-Anderson Act applies to transportation of radioactive materials as well as operation of the plants. (On January 4, 1980, the NRC published findings that the Three Mile Island incident did not result in damages covered by the insurance program)

Companies which operate power reactors are required to maintain insurance to the maximum amount available from the private market. In 1979, that amount was $140 million (per incident). This coverage is provided by insurance pools.

If an accident were to occur which was not covered by this $140 million, the insurance pool would then assess each nuclear licensee a premium of up to $5 million per operating reactor. In the middle of 1978, this assessment would have raised an additional $340 million, for a total of $480 million. The utilities also sign indemnity agreements with the U.S.N.R.C. to provide guarantees to the federally required minimum of $560 million.

The Price-Anderson Act was revised in 1975; the federal indemnity is being phased out as private coverage grows. Today that indemnity amount, $80 million, is the difference between the $480 million provided by the pools and their assessments, and the $560 million required by the Act. Originally, the amount of federal participation was $500 million. Through 1978, total payment of insurance claims, from all nuclear causes (some not a part of the nuclear power program), totaled $614,000. No claim has ever required payment from the governmental indemnity and the $20 million in fees (for indemnity coverage) paid by nuclear power companies has gone into the federal general treasury.

The government provides indemnity coverage in other areas as well, including crop insurance, bank deposit insurance, savings and loan account insurance, FHA and VA housing mortgage insurance, medicare and medicaid, maritime vessel mortgage insurance, veterans life insurance, unemployment insurance, Social Security, and government employees insurance.

The dollar figure limits the liability of the insurance companies, but it does not limit the amount which might be paid for personal or property losses. Congress is committed, by law, to provide whatever additional compensation may be needed. Provision has been made for immediate payment to cover costs of emergency shelter, food, and medical care.

Other Insurance

Business insurance rates and levels of coverage have been reasonably easy to set because fires, releases of toxic materials, etc., happen with some frequency. As a result, insurance companies have sufficient data to estimate frequency and probable damage.

In the case of the nuclear industry, this formula didn't work. Because of "very small probability/potentially large consequence," the system set up by the Price-Anderson Act was developed in 1957.

Life insurance companies recognize no increase in hazards for those policy-holders living near commercial nuclear power plants.

POLICY DECISIONS

In view of the present fluid condition of United States' energy policy in general and nuclear policy in particular, the participants in this course have an opportunity to influence the formation of such policy through their congressional delegations. A conscientious study of the material in this course and of the material in the bibliographies can result in rational conclusions concerning the issues relative to nuclear energy and the alternative sources. These conclusions should be communicated to your representatives in Congress, as well as to the elected officials in your community.

131

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CITIZEN EDUCATION ON NUCLEAR
TECHNOLOGY

VI-DECISION MODULE

INTRODUCTION

Volumes have been written on the subject of "decision making," particularly on decision making at the national level, not all of which is very understandable to the average reader. At the community level, however, the local residents usually know what they want. The problem is that individuals usually have conflicting desires, and their perception of how to satisfy those desires leads to additional conflict. Sound decisions at the community level, therefore, must be made through the democratic process.

The democratic process, as used here, is understood to mean not the forcing of the majority opinion on an unwilling minority, but rather the resolution of opposing opinions and desires through compromise based on a rational consideration of fact and the realities of the situation. To that end, this decision module focuses on a process. In a recent review of the literature on decision making, Charles O. Jones[1] decrys the emphasis on procedures and organization, and lack of substance in that literature. He identifies four "components of decision making: the issues, the participants and their expectations, organization and processes, and proposals and programs." In the present context, the issue is simple - "to build, or not to build a nuclear power plant." The participants and their expectations are also defined. The proposals and programs are the result of the deliberations of the community participants. There remains, then, the process by which these proposals and programs are developed.

The elected officials of local, state, and federal governments are the ones in our society who make all final decisions in community matters. That does not mean, however, that private citizens cannot have some voice in the conduct of community affairs. How influential that voice might be will depend almost entirely on how well-informed that voice is in the matter at hand. It is advisable, therefore, that communities inform themselves of the facts in the case.

A program such as the CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY can do that. The material in this unit was designed to provide a framework for the use of community groups in formulating a position on the issues in question.

Many voices, all competing for the attention of community officials, is not the way to gain their attention. Organized groups are much more effective. It is recommended, therefore, that community residents concerned about the existence, or proposed existence, of a nuclear power plant should organize themselves into an advisory group constructed along standard organizational principles to the end that, as a group, their considered opinion might carry some weight with the officials charged with making the pertinent decisions. Existing service clubs, such as Rotary, Kiwanis, or Civitan clubs can serve as the parent organization for that purpose.

The following material has been designed for the use of such groups to help them arrive at informed and well-thought-out positions on energy questions in their community.

PURPOSE

The purpose of this Decision Module is to provide an outline for use by local community groups to assess community attitudes and to formulate recommendations to civil authorities. Although the program is primarily intended to deal with nuclear technology, much of the procedure is applicable to any industrial development.

ELEMENTS OF DECISION MAKING

The elements of decision making are conceived as follows:

1. Establish priorities
2. Explore alternative means for attaining those priorities.
3. Select the most acceptable alternative.
4. Develop a plan for implementing that alternative.

When a decision has been reached, the process moves into the Implementation phase. This latter phase is the function of the civil authorities; community advisory groups can only assist those authorities in making the necessary decisions for the attainment of the established priorities.

Establishing Priorities

Community goals arranged in the order of their importance to the community residents (priorities) must be set by those residents themselves. Following are some possible goals listed in no particular order.

TABLE VI-1

Community Goals

a. Clean air
b. Health and safety of community residents
c. Low cost, dependable electricity
d. Agricultural considerations
e. Industrial expansion
f. High quality education for the community's youth
g. Continuing education for adults

Explore Alternatives

A list of alternatives for each of the above goals can next be made. Since this program deals specifically with energy, the various energy alternatives are given in Table VI-2. Detailed analyses may be found in Annual Review of Energy.(2)

No attempt will be made here to list alternatives for the other goals because viable alternatives depend strongly on the local situation and local residents are best qualified to know what they are.

TABLE VI-2

Energy Alternatives

Solar Energy

Advantages

a. Non-polluting
b. Widespread availability
c. Continuing costs low
d. Ideal for low-potential, dispersed applications

Disadvantages

a. A very low-density source
b. Capital costs and space requirements prohibitive for large scale applications
c. Not suitable for mobile applications, except in spacecraft
d. Large storage capacity needed

Wind Energy

Advantages

a. Non-polluting
b. Widespread availability
c. Low maintenance, automatic operation possible
d. Total potential high
e. Unduly complicated machinery not needed
f. Ideal for low-potential, dispersed applications

Disadvantages

a. An intermittent, erratic source
b. Large storage capacity needed
c. Not directly applicable to mobile application
d. Capital cost of large scale applications likely to be high
e. Relatively strong winds needed for large scale applications

Coal Energy

Advantages

a. Very large quantities available
b. A high energy density source
c. Applicable technology well developed
d. Public acceptance very high
e. Convertible to forms suitable for mobile applications

Disadvantages

a. Cost of installing anti-pollution devices very high

b. Solid waste a significant fraction of original fuel weight and/or bulk

c. Effect on world climate due to resulting carbon dioxide is complicated, and as yet, relatively unknown

d. Badly polluting as currently applied

Oil and Gas

Advantages

a. A high energy-density source

b. Applicable technology well developed

c. Public acceptance very high

d. Ideal for mobile applications

Disadvantages

a. In short supply

b. Can be polluting

c. Limited supply leads to monopolistic control

Nuclear Energy

Advantages

a. Pollution minimal

b. Very high-density source

c. Cost competitive with other sources

d. Long-term operation with low refueling costs

e. Ideally adapted to large-scale operation

f. Supplies adequate for long-term operation

Disadvantages

a. Extensive measures to guard against radiation exposure are needed

b. Nuclear "ashes" are very radioactive and require careful handling to avoid radiation exposure

c. Not suitable for mobile applications

d. High initial capitalization

e. Political climate results in long delays in implementation

Geothermal Energy

Advantages

a. A high energy density source
b. Relatively non-polluting
c. Low fuel cost
d. Probably a long-term source
e. Basic technology well developed
f. Suitable for space heating, if favorably located
g. Suitable for low-potential applications, such as in agriculture

Disadvantages

a. Must be developed on-site, which may be remote from use areas
b. Not suitable for mobile applications
c. Disposal of thermally-spent fluids a problem
d. In some areas, the dissolved minerals may present problems

Hydro-Electric

Advantages

a. Non-polluting
b. High energy-density source
c. Low maintenance cost
d. A renewable source

Disadvantages

a. In limited supply
b. Must be developed where found
c. High initial capitalization costs
d. Not suitable for mobile applications

Other possible sources that may have a limited application in certain areas are thermal gradients in the ocean, tidal energy, ocean wave motion, biomass sources, and waste heat from industrial processes.

Select Acceptable Alternatives

Advantages and disadvantages listed in Table VI-2 form the basis for selection in the energy case. The listing, however, is only suggestive, and factual data pertinent to each of the listed items must be determined locally. The material contained in the five units provides some of that factual data.

Which of the advantages and disadvantages are considered to be of overriding importance is a matter of personal preference and must be established by democratic action.

Develop a Plan

Successful planning implies not only that the plan is logically sound and feasible, but also that it is acceptable to community residents, complies with local laws and restrictions, and has the support of civil authorities. A strong public relations effort should therefore receive as much attention as the strictly technical aspects.

In addition to the technical, environmental, and economic factors implied in the foregoing list of energy alternatives, sociological factors need to be considered when developing a plan.

That plan must resolve questions derived from community attitudes, preparedness, and education. This, too, requires an application of the democratic process, since personal preferences, for which there is no accounting, will be the main hurdle to overcome. In the sociological area, there are few objective factors.

MATERIALS FOR DECISION MAKING

Sound decisions, whether personal or public, can only be based on factual information. Unfortunately, total information is rarely attainable, but in most instances, some kind of decision is imperative. The only recourse, then, is to employ whatever experience-based judgement is available. That is, when information is lacking, one must rely on the judgement of experts.

The five units presented above were prepared on the basis of the best information available, plus some opinions of experts. The bibliography lists additional sources of more detailed information. These and other sources to be found in public libraries should be consulted by interested persons and anyone charged with making pertinent decisions.

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CITIZEN EDUCATION ON NUCLEAR TECHNOLOGY (CENT)

ACKNOWLEDGEMENT

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